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Study of coronal mass ejections with solar activity and geomagnetic index

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Abstract

In the present study we have investigated the some statistical properties such as occurrence rate, speed of halo partial halo CMEs and all type of CMEs observed during the periods 1996 to 2014 by using solar heliospheric observatory (SOHO) and large angle spectrometric coronagraph (LASCO) data. We investigate the relationship between coronal mass ejection (CMEs), Sunspot number (Rz) and geomagnetic index Ap variations of long term basis. The 650 halo, 1692 partial halo, and 24641 all CMEs which include halo and partial halo event have been observed for the solar cycle 23 to ascending phase of recent solar cycle 24,(years 1996 to 2014). It has been found that the positively correlated between linear speed (Km\sec) all CMEs, halo event CMEs, PHalo event CMES, with sunspot number and geomagnetic index. We found that the rate of occurrence of CMEs is good correlated with sunspot number (Rz) and geomagnetic index (Ap).

Keyword- Coronal mass ejection, Sunspot number geomagnetic index, linear speed, halo, partial halo event and correlation coefficient.

Introduction-

When coronal mass ejections (CMEs) erupt from the sun, high speed particles and strong magnetic field can hurl earthward thus causing a significant impact on the near Earth space environment (geomagnetic storms) such as adverse effects on satellites and communications, electric power, pipelines etc. numerous severe storms occur during the maximum phase of the solar cycle and they are mostly associated with CMEs (Gopalswamy et. al. 2007, Zhane et al. 2007). Disturbances of the near Earth environment are measured by various parameters, such as Ap (Bartels et al. 1939).

Coronal mass ejections CMEs are important sources of solar variability from the point of view of plasma and magnetic field. The CMEs remove billions of tons of magnetized plasma from the sun and dump them into sun and the earth connected space once every day during solar minimum and several times per day during solar maximum. The coronal mass ejection are the most energetic events in the heliosphere and are widely recognized as being responsible for production of large disturbances in solar wind, sunspot and geomagnetic. Yashiro et al. (2003) have studied the properties of (CMEs) observed with large angle and spectrometric coronagraphs (LASCO) on board solar and heliospheric observatory (SOHO). Gopalswamy et at. (2003a) have described the solar cycle variation of different properties of CMEs such as average, median speeds, daily occurrence rate and latitude of solar sources for the periods 1996 to 2003.The measured properties of CMEs include their angular widths, speeds, acceleration masses and energies occurrence rate, locations relation to the solar disk have been also discussed by many researches St Cycer et al. 2003, Weeb 2002. The occurrence rate per day of all

CMEs found to be ~ 3 during the study periods. It is also observed that the rate of occurrence of CMEs is good correlated with solar activity. The halo CMEs (wide) appear to faster and more energetic than non halo CMEs (M.P.yadav, 2015).

Coronal mass ejection which are earth directed celled halo event because of the way they in chronograph images. As expanding cloud of an earth directed CMEs looms larger and larger it appear to envelop the sun, forming a halo around our sun. In this study only halo and partial halo CMEs has been taken into consideration. Several investigators with solar flares and CMEs have been studied the asymmetric cosmic ray intensity decreases (Fds) event. CMEs, are the explosions in the suns corona. CMEs from the solar corona are the most spectacular phenomena of solar activity. CMEs occur in regions of closed magnetic fields that overlie magnetic inversion lines Hundhausen 1993. Population of halo CMEs and their average speeds increases during solar maximum and their occurrence generally fallow the phase of solar cycle, during solar minima. One CMEs occurs every other day. The rate goes up to several per day during solar maximum 13 CMEs were recorded by SOHO. There were several days with more than 10 CMEs. The rate of CMEs and the minimum to maximum variability originally thought to be inadequate Newkirk G. Jr. et al.1981, Wanger W.A. 1984.

Methodology-

The data for CMEs have been taken from the catalog by the central for solar physics and space weather (http://cdaw.gsfc.hasa.gov\cme.list). In our analysis, the daily value of sunspot number (Rz) and geomagnetic index (Ap) have been used over the periods 1996 to 2014, covering solar cycle 23 to ascending phase of current solar cycle 24. The date has been taken for the website www.ominweb.gsfc.nasa.gov. CMEs properties observed from LASCO on board SOHO. We have taken in account all CMEs which in clued halo and partial halo CMEs during the study periods. A CMEs is said to be halo if angular width is equal to 360 where as a partial halo CMEs have angular width greater than 120 and less than 360. We have also count total number of CMEs containing angular width greater than 0 and less than 360 which are occurred during the study periods 1996 to 2014. We have analyzed the data statistically.

Result and Discussion-

We have investigated the some statistical properties such as occurrence rate, speed of halo, partial halo and all type of CMEs observed during the 1996 – 2010 by using solar heliospheric observatory (SOHO) and large angle spectrometric corona graph (LASCO) data Yadav M.P. 2015. Using the daily value of sunspot number (Rz), geomagnetic index (Ap) and coronal mass ejection (halo, partial halo and total number of days or all CMEs) 24 hours disturbance for yearly event, are calculated for the solar cycle 23 to ascending phase of recent solar cycle 24. Fig. 1 Shows the annual mean value of CMEs (halo, partial halo and total number of days or all CMEs) event for the periods 1996 to 2014, as shows in fig. 1 have investigated 24641 all CMEs which include halo plus partial halo CMEs. The 650 halo and 1692 partial halo CMEs have been identified for the periods 1996 to 2014.In solar cycle 23, 398 halo events, 867 PHalo event and all CMEs 14761 were observed whereas, in recent solar cycle 24, periods (2009 to 2014) 253 halo 827 partial halo and all CMEs 10626 were observed. It is found that the number of CMEs (PH event) are large in comparison to CMEs halo event in both solar cycle 23 to recent solar cycle 24 (fig.1).

Maximum number of CMEs (Halo event) are observed in year 2001, 63 event of solar cycle 23 and year 2012, 84 event and 2014, 62 event of recent solar cycle 24, and maximum number of CMEs PH event are observed in year 2001, 150 event of solar cycle 23, PH event are observed in year 2014, 246 event of solar cycle 24. Variations correlated with solar activity cycle were reported earlier for CMEs occurrence rate and speeds (Webb & Howard 1994, Gopalswamy et al. 2003), latitude distribution Gopalswamy et al. 2003, angular widths (Kahler et al.1989). Fig. 2,4 and 5 Shows that annual mean value of sunspot number (Rz) for the periods 1996 to 2014. It is observed for fig. 2, 4 and 5 that the year 2000 is the maximum activity year. The SSNs are increase from 1996 to 2000, which is the inclining phase and decreases for the periods 2000 to 2008, which is the declining phase of solar cycle 23, SSNs are increase for the periods 2008 to 2013 which is the inclining phase, and decreases for the periods 2013 to 2014, which is the declining phase of recent solar cycle 24. This result is consistent with St Cyr et al. 2000 and Gopals wamy et al. 2005, 2006b). In fig. 2, 4 and 5 Shows the relationship between annual number of sunspot number (Rz) with all CMEs linear speed (Km\Sec), average speed (Km\Sec) CMEs halo, and average speed (Km\Sec) CMEs partial halo for the solar cycle 23 to recent solar cycle 24. The cross correlation coefficient between SSNs (Rz) with all CMEs linear speed (Km\Sec) , SSNs (Rz) with average speed (Km\Sec) CMEs halo, and SSNs (Rz) with average speed (Km\Sec) CMEs partial halo have been found to be 0.838, 0.612 and 0.807 thus, we conclude that Rz is very good positive correlated with all CMEs linear speed (Km\Sec). To the contrary, the CMEs maximum speed index, studied here, is based on the highest daily CMEs speed measurement averaged over a month. We thus select only the maximum speed, so the super active regions get higher weight because they produce high speed CMEs in greater numbers (Kilcik et al. 2010). In fig. 3 and 6 Shows the relationship between annual number of geomagnetic index (Ap) with all CMEs linear speed (Km\Sec) and average speed (Km\Sec) CMEs halo for the periods of 1996 to 2014, which shows that annual number of geomagnetic index (Ap) with all CMEs linear speed (Km\Sec) and average speed (Km\Sec) CMEs halo are positively – correlated. We have noticed that minimum average speed of all CMEs is 255.21 Km\Sec in year 2007, whereas maximum average speed of all CMEs is 542.16 Km\Sec in the year 2003. Furthermore, 143 Km\Sec is the average speed of halo CMEs in year 2008 which is minimum whereas 1400.96 Km\Sec is the maximum average speed of halo CMEs during the year 2003 and geomagnetic index (Ap) that minimum value of 3.92 in year 2009, whereas maximum geomagnetic index (Ap) is 21.75 in the year 2003. Thus, we can conclude that maximum average speed of all CMEs, average speed (Km\Sec) CMEs halo and geomagnetic index (Ap) have been occurred in same year 2003, which is not the year of maximum activity. Fig. 7 shows the combine effect of CMEs event (halo, partial halo and all CMEs) for the periods 1996 to 2014. It is apparent for fig.7 that more than 6.87% CMEs partial halo event where as 2.64% CMEs halo event are identified. Fig.7 shows the relationship between CMEs event (halo, partial halowith all CMEs) are positively correlation.

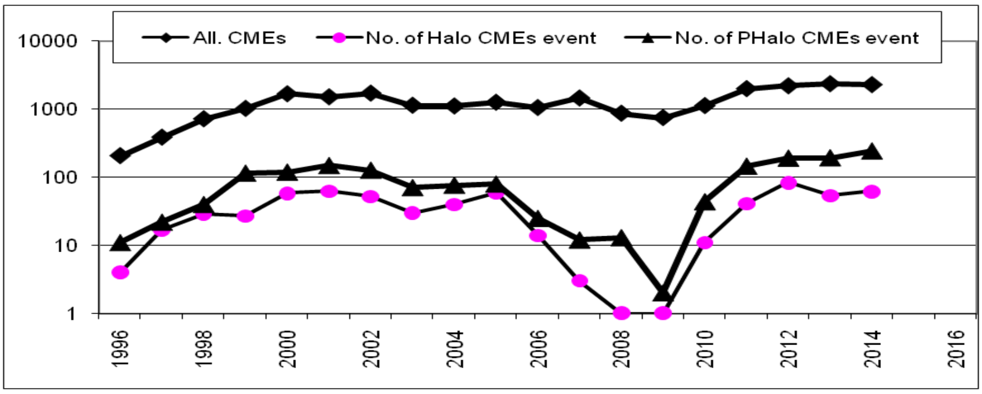

Fig.:- 1 Shows the annual distribution of Halo, Partial Halo and All CMEs from 1996 to 2014.

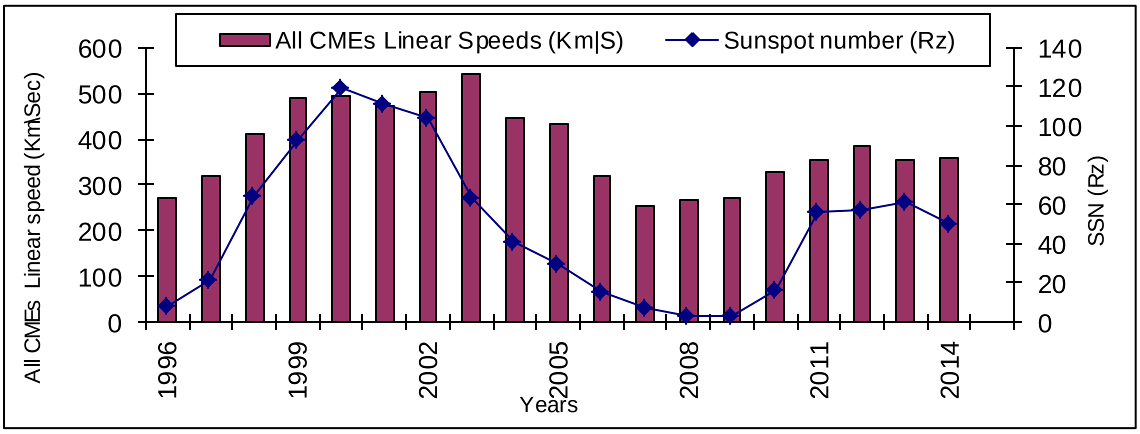

Fig.:- 2 Shows the all CMEs linear speed (Km\Sec) and annual mean values of sunspot number for the periods 1996 to 2014.

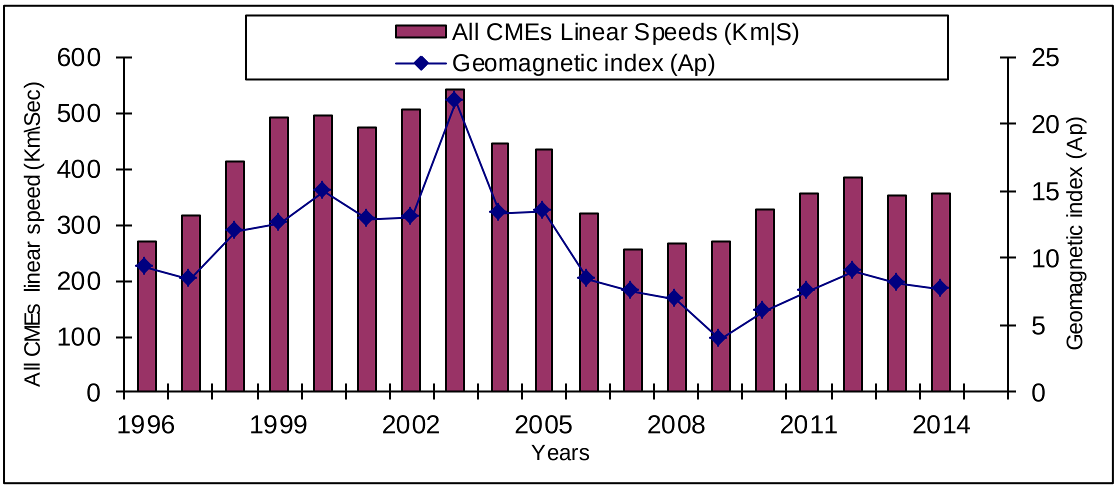

Fig.:- 3 Shows the all CMEs linear speed (Km\Sec) and annual mean values of geomagnetic index (Ap) for the periods 1996 to 2014.

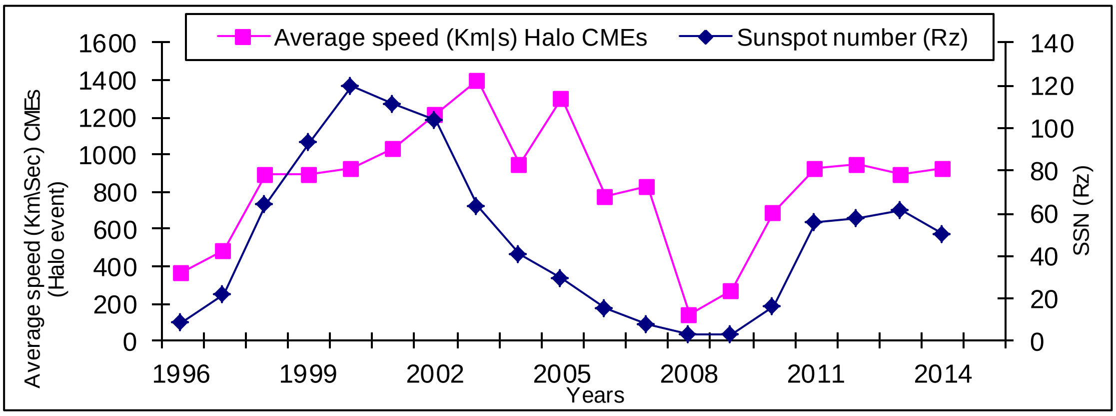

Fig.:- 4 Shows the average speed (Km\Sec) halo CMEs and annual mean values of sunspot number for the periods 1996 to 2014.

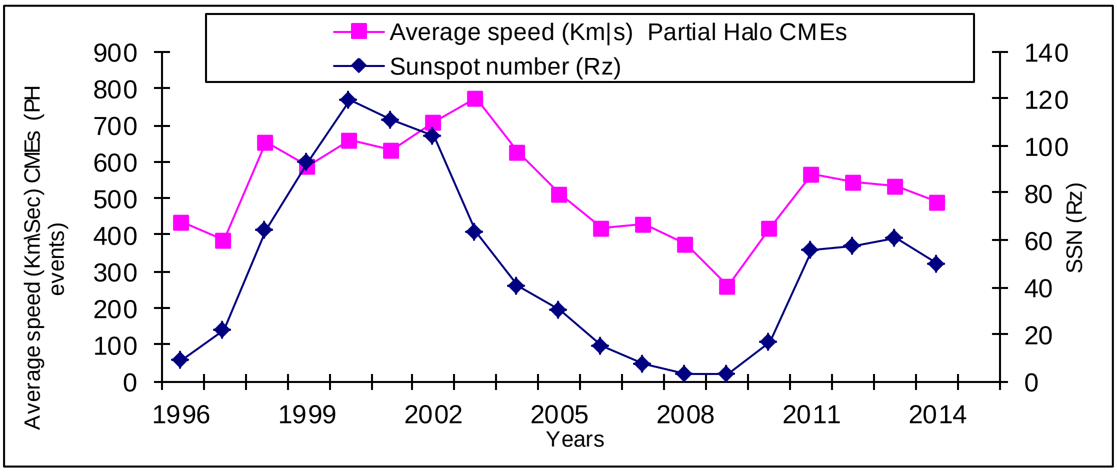

Fig.:- 5 Shows the average speed (Km\Sec) partial halo CMEs and annual mean values of sunspot number for the periods 1996 to 2014.

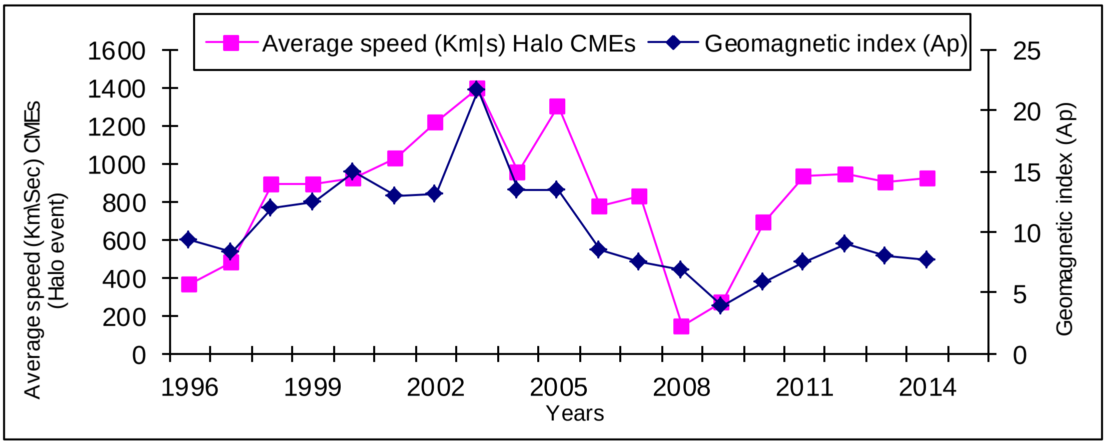

Fig.:- 6 Shows the average speed (Km\Sec) halo CMEs and annual mean values of geomagnetic index (Ap) for the periods 1996 to 2014.

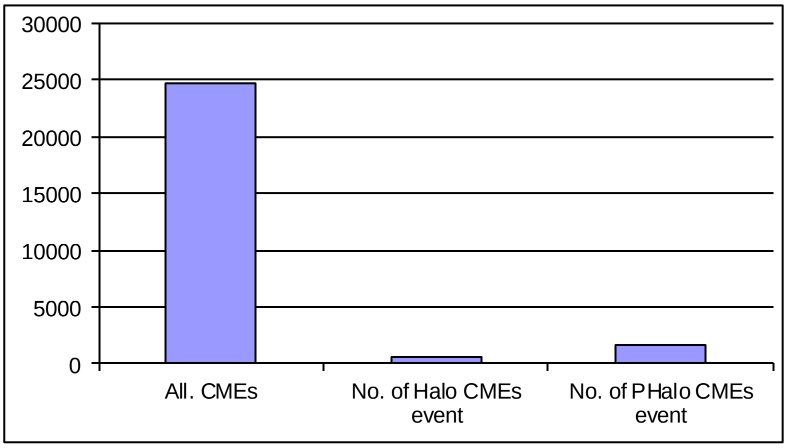

Fig.:- 7 Shows the Association of full Halo CMES , partial Halo CMEs with all CMEs for the periods 1996 to 2014.

Conclusions-

The present study, the following conclusions have been drawn.

1. The occurrence of halo CMEs is minimum (1) at the solar minimum 2008, 2009 and maximum 84 second solar maximum year 2012, respectively where as the partial halo CMEs minimum 02, 2009 and maximum 246, 2014 . Halo and partial halo CMEs are detected at the rate of 2.64% and 6.87% of all CMEs.
2. The minimum and maximum average speed of halo CMEs have been observed to be 143 Km\Sec year 2008 and 1400.96 Km\Sec year 2003, respectively where as the average speed of all CMEs have been observed to be 255.21 Km\Sec year 2007 and 542.16 Km\Sec year 2003.
3. The maximum average speed of CMEs halo and all CMEs have been observed to be 1400.96 Km\Sec and 542.16 Km\Sec during the same year 2003.
4. The SSNS versus linear speed (average speed) all CMEs and average speed of partial halo CMEs strongly positive correlated during solar cycle 23 to recent solar cycle 24.
5. The geomagnetic index (Ap) versus linear speed (average speed) all CMEs and average speed of halo CMEs strongly positive correlated during solar cycle 23 to recent solar cycle 24.
6. The halo CMEs event with partial halo CMEs event good positively correlation for the periods 1996 to 2014.

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