Research Paper

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"Coronal Mass Ejection (CME) Events in the Ascending Phases of Solar Cycle-23 and 24 - A Comparative Study"

Physics

KEYWORDS : Coronal Mass Ejections (CMEs), Ascending Phase of Solar Cycle-23 (1996-2000), Ascending Phase of Solar Cycle-24 (2008-2012).

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ABSTRACT

We have analyzed the coronal mass ejections (CMEs) events for the ascending phases of solar cycle-23 and 24 i.e. for the time of interval 1996-2000 and 2008-2012 respectively. According to width distribution of CMEs we have find that, halo CMEs are 3% of total in the ascending phase of solar cycle-23 but in the ascending phase of solar cycle-24 only 2% of total CMEs are halo, whereas according to speed distribution of CMEs, Coronal Mass Ejections of higher speeds i.e. >1500 km/sec are only 1% of total in the ascending phase of solar cycle-23 and in the ascending phase of solar cycle-24 only 0.32% (~ 0%) of total CMEs having speed >1500 km/sec, but on the basis of total occurrence of CMEs in the ascending phase of solar cycle-24 (2008-2012), 63% CMEs are occurred whereas in the ascending phase of solar cycle-23 (1996-2000) only 37% CMEs are occurred.

INTRODUCTION:

Coronal mass ejections are huge bubbles of gas ejected from the sun over the course of several hours (Brueckner, 1974; Macqueen et al., 1974). CMEs were identified more than 30 years ago by Tousey (1973) in the OSO-7 data. Coronal mass ejections (CMEs) are an eruption of magnetized plasma from the sun, seen as bright features expanding outwards from the corona in the coronagraph images, the CME further propagates in the interplanetary medium to become an interplanetary coronal mass ejection (ICME) (Bothmer and Duglis, 2007). Coronal mass ejections (CMEs) bring about large scale changes in the corona, which have fundamental implications for the evolution of the magnetic flux of the sun, ultimately related to the solar dynamo (Low, 2001).

CME exhibit various observational signatures depending on their age and location of observation in the heliosphere. Billions of tones of material are dumped into the solar wind during each ejection and several CMEs can take place on a single day during the maximum of solar activity cycle (Gopalswamy, 2002). Separating the CMEs according to their linear speed, their width and their kinetic energy a detailed study during the rising and the declining phase of solar cycle-23 has been performed by Gerontdou et al., 2009).

A more copious data set for CMEs is now available from the Solar and Heliospheric Observatory (SOHO) mission's Large Angle and Spectrometric Coronagraph (LASCO), which images the corona continuously since 1996, covering a field from 1.5 R_s to 32 R_s (Kane, 2006).

CME rate of 0.5 CME/day was derived from the OSO-7 coronagraph data (Tousey et al., 1974). Webb and Howard (1994) found a rate of 0.31 to 0.77 CME per day for the solar minimum years and 1.75 to 3.11 CMEs per day for the solar maximum years.

DATA DETECTION AND METHOD OF ANALYSIS:

We have taken the CMEs data for the first five years of the both cycles-23 and 24, i.e for the time period of 1996-2000 and 2008-2012, termed as the ascending phases of solar cycle-23 and 24 respectively.

In our present study we have taken the data for CMEs from SOHO/LASCO CME catalog/search the entire catalog, through the web. We have choose the CMEs for the ascending phases of solar cycle-23 and 24, i.e. for the time interval of 1996-2000 and 2008-2012 respectively on the basis of occurrence of their angular width and speed. For these periods we have distributed the angular width of CMEs on four categories as 60^0, $61\sim120^0$, $121^0\sim359^0$ and $=360^0$ (halo), CMEs on the basis of speed are also classified into four categories as 500 km/sec, 501~1000 km/sec, 1001~1500 km/sec and >1500 km/sec. Then we have used the pie-diagram to investigate the occurrence percentage of CMEs for above categories.

DISCUSSION AND RESULTS:

We have distributed the our study in three parts (i) Distribution of total CMEs according to angular width (ii) Distribution of total CMEs according to their Speed and (iii) Distribution of total CMEs for the period 1996-2000 and 2008-2012 as discussed below:

(i) Distribution of total CMEs according to Angular Width:

In this study, we have characterized the CME events according to their angular width wise distribution for the ascending phases of solar cycle-23 and 24, i.e. for the period 1996-2000 and 2008-2012 respectively on the basis of total occurrence for this period. We have categorized the annual CMEs events in four categories, [1] CMEs having width $\leq60^0$, [2] CMEs having width $61^0\sim120^0$ [3] CMEs having width $121^0\sim359^0$ and [4] CMEs of width $=360^0$ (Halo CMEs).

Fig.1, shows the pie-diagram for the occurrence of total CMEs on the basis of their angular width for the period 1996-2000 (ascending phase of solar cycle-23), and we observed from fig.1, that CMEs having [1] angular width $\leq60^0$ are 61%, [2] CMEs having width $61^0\sim120^0$ are 28%, [3] width $121^0\sim359^0$ are 8%, and [4] halo CMEs (having width $=360^0$) are occurred only 3% of total CMEs during the ascending phase of solar cycle-23.

Fig.2, shows the pie-diagram for the occurrence of total CMEs on the basis of their angular width for the period 2008-2012 (ascending phase of solar cycle-24). We observed from this figure that the 77% CMEs occurring in between this time period having angular width $<=60^0$, 15% CMEs occurred with angular width $61^0\sim120^0$, 6% CMEs having angular width $121^0\sim359^0$ and only 2% CMEs are halo (having width $=360^0$) during this period.

(ii) Distribution of total CMEs according to their Speed:

In this study, we have characterized the CME events according to their distribution on the basis of their speed for the time interval of 1996-2000 and 2008-2012 by means of total occurrence for this period. We have divided the CME events speed-wise in four categories [1] CMEs with speed ≤ 500 km/sec [2] CMEs

with speed 501~1000 km/sec and [3] CMEs occurring with speed 1001~1500 km/sec and [4] CMEs of higher speeds, i.e. having speed >1500 km/sec.

Fig.3, shows the pie-diagram for the distribution of CMEs according to above four categories of speed for the time interval of 1996-2000. Here we observed that all these four categories of CMEs events, i.e. ≤ 500 km/sec, 501~1000 km/sec, 1001~1500 km/sec and >1500 are 67%, 29%, 3%, 1% respectively for the ascending phase of solar cycle-23.

Fig.4, shows the pie-diagram between four categories of CMEs speed and we have observed that the occurrence of CMEs of these categories, i.e. ≤ 500 km/sec, 501~1000 km/sec, 1001~1500 km/sec and >1500 km/sec are 85%, 14%, 1% and 0% respectively for this time of interval (ascending phase of solar cycle-24). Here it is important to note that the CMEs having higher speeds (i.e. >1500 km/sec) are not exactly 0% but their occurring percentage is in fraction, which is considered as 0% for the period 2008-2012.

(iii) Distribution of total CMEs for the period 1996-2000 and 2008-2012-

Fig.5, shows the pie-diagram for the occurring of total CMEs for the period 1996-2000 and 2008-2012, i.e. for the ascending phase of solar cycle-23 and 24. We found that in the ascending phase of solar cycle-24 (2008-2012), 63% CMEs are occurred whereas in the ascending phase of solar cycle-23 (1996-2000) only 37% CMEs are produced.

FIGURES:

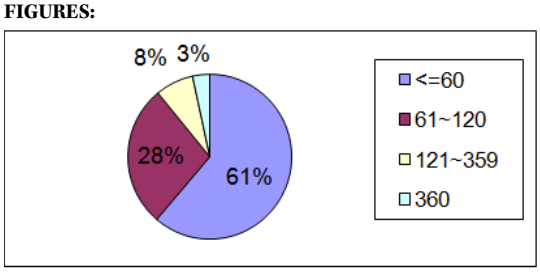

Fig.1, shows the pie-diagram for the occurrence of total CMEs distribution on the basis of their angular width for the ascending phase of solar cycle-23, i.e. for the period 1996-2000.

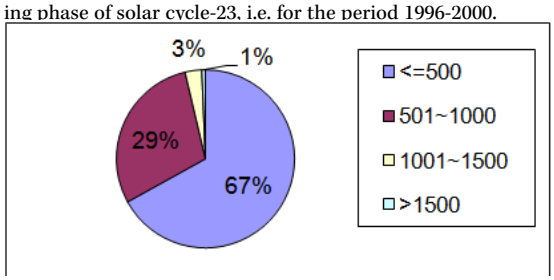

Fig.2, Shows the occurrence of total CMEs on the basis of their angular width for the ascending phase of solar cycle-24, i.e. for the time interval of 2008-2012.

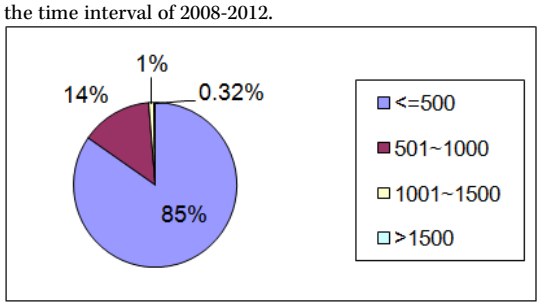

Fig.3, shows the occurrence of total CMEs on the basis of their speed for the ascending phase of solar cycle-23, i.e. total CMEs for the time interval of 1996-2000.

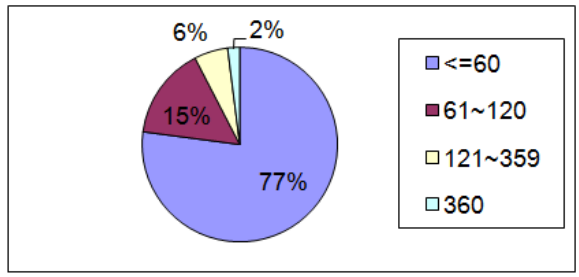

Fig.4, shows the occurrence of total CMEs on the basis of their speed for the ascending phase of solar cycle-24, i.e. total CMEs for the time interval of 2008-2012.

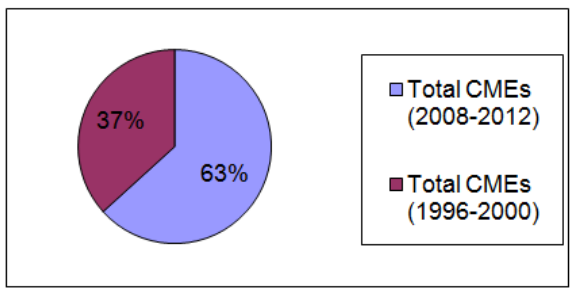

Fig.5, shows the pie-diagram between occurrence of total CMEs for the ascending phases of solar cycle-23 & 24, i.e. for the period of 1996-2000 and 2008-2012 respectively.

CONCLUSIONS:

(i) According to Width distribution of total CMEs: The occurrence of CMEs of higher width i.e. halo CMEs are 3% of total in the ascending phase of solar cycle-23 whereas in the ascending phase of solar cycle-24 only 2% of total CMEs are halo.

(ii) According to Speed distribution of total CMEs: The occurrence of CMEs of higher speeds i.e. >1500 km/sec are only 1% of total in the ascending phase of solar cycle-23 whereas 0.32% (~ 0%) of total CMEs having speed >1500 km/sec.

(iii) Distribution of total CMEs: In the ascending phase of solar cycle-24 (2008-2012), 63% CMEs are occurred whereas in the ascending phase of solar cycle-23 (1996-2000) only 37% CMEs are produced.

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