Relation between Coronal Mass Ejections and Solar activity for solar cycle 23

Pankaj K.Shrivastava*, and Animesh M.Jaiswal*

**Department of physics, Govt. Model P. G. Science College, Rewa, M.P.,INDIA*

***Abstract*. Based on SOHO/LASCO catalogue and solar geophysical data book, we studied the relationship among CME rates, speed of full halo and partial halo CMEs for solar cycle 23. It is investigated from the analysis that the average speed of full halo CMEs is almost faster than the annual average speed of partial halo CMEs. The maximum average speed of halo CMEs is found to be as large as1400 km/sec whereas minimum speed of halo CMEs is some time of the order of 350 km/sec. CMEs are predominantly from sunspot regions(except for some CMEs associated with low latitude quiescent prominces). Frequency varies according to the solar sunspot cycle. It is inferred that the correlation between them is positive and also found two peaks in CME and only one peak in sunspot line.**

***Keywords*: Coronal mass ejection, Sunspot number, solar cycle, Flare**

I. INTRODUCTION

CMEs are the explosions in the suns corona. Coronal Mass Ejections 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[1]. A study on CMEs is an important topic that relates directly to space environments . Within CMEs we have also Halo CMEs, appear as enhancement surrounding the entire occulting disk looks like a roughly circular Halo surrounding the sun. The Halo CMEs are more likely to impact the earth those of which are right angles to the earth - sun line[2]. 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 CME occurs every other day. The rate goes up to several per day during solar maximum. On one 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 [3, 4]. The CME activity should fallow rather closely to the Sunspot cycle, but the correlation in exact counts may not be precise. This is probably because CMEs happen in layers of the sun that are much higher above the solar surface than the Sunspots. In this work, we have derived the relationship between Comes and sunspot numbers for the solar cycle 23.

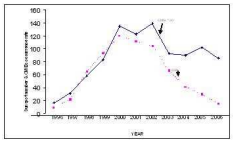

Fig. 1. Shows the linear plot for annual occurrence rate of CMEs and sunspot numbers For the period of 1996 to 2006 in lower panel.

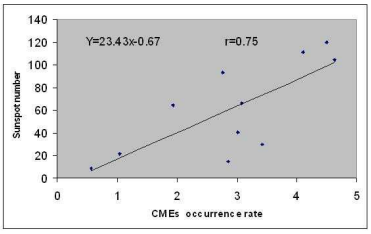

Fig. 2. Cross correlation between occurrence rate of CMEs and Sunspot number for 1996 t0 2006.

II. METHODOLOGY

The data used in this study was obtained by the Large Angle Spectroscopic Coronagraph (LASCO) in structure aboard the solar and Helosheric Observatory (SOHO) Mauna Loa coronagraphs and Solar Geophysical data. In the present study, we have analyzed the speed of all Full Halo CMEs and Partial Halo CMEs for 23 solar cycles. Angular width only 360 0 consider a Full Halo CMEs and angular width¿/120 0 has been consider as Partial Halo CMEs.

III. RESULT AND DISCUSSION

Mass motion is the basic characteristic of CMEs, quantified by the speed coronagraph obtain image with a certain time cadence, so when a CME occurs, the leading edge progressively appears at a greater heliocentric distance. By tracing CME feature in successive frames.

One can drive the speed of the feature for the studying the variation of speed one has to use higher order fits. It is noted that the average speed of halo CMEs is roughly twice that the general population of CMEs.We have

TABLE I
NUMBER OF CMES ALONG WITH AVERAGE SPEEDS.

Year	All CMEs	Types of CMEs	No. of events	Average speed (Km/S)
1996	206	Halo	4	366
		Partial Halo	11	439.09
1997	381	Halo	16	450.37
		Partial Halo	21	358.9
1998	709	Halo	27	928.88
		Partial Halo	38	883.14
1999	1011	Halo	26	899.53
		Partial Halo	1108	551.21
2000	1644	Halo	53	917.26
		Partial Halo	116	655.84
2001	1498	Halo	63	1030.26
		Partial Halo	1145	638.12
2002	1691	Halo	46	1209.36
		Partial Halo	121	712.95
2003	1127	Halo	30	1400.96
		Partial Halo	70	756.69
2004	1101	Halo	40	953
		Partial Halo	74	633.74
2005	1247	Halo	57	1324.22
		Partial Halo	77	518.85
2006	1043	Halo	13	775.46
		Partial Halo	24	
Total	11658	Halo	375	
		Partial Halo	805	

observed total 11658 CMEs during the period of solar cycle 23.Out of 11658 CMEs, 375 are full halo and 805 are partial halo. CMEs will become more and more frequent as we near solar maximum. All the vales are given in table1: 1. A rate of 0.5 CMEs /day was derived from the OSO-7 corona graph data[5,6] . According to Probhas Raychaudhuri[2] the occurrence of average CME rate is 121.51 per month during June 1999 to June 2003 (Sunspot maximum range) where as the occurrence of average CME rate is 41.24 during January 1996 to May 1999(Sunspot minimum range), although during the year 1996(when the average Sunspot number is 8.6 per month) occurrence of average CME rate is 18.16 per month. We find out that in Sunspot minimum phase 1996 the occurrence rate is minimum of 23 solar cycle , that is 0.56 Comes per day where as in Sunspot maximum phase 2002, the occurrence rate is maximum for 23 solar cycle that is 4.63 CMEs per day. The average CMEs occurrence rate for 23 solar cycle is 2.9 CMEs per day. Fig .1 Shows the occurrence rate of CMEs per year for 23 solar cycle. The occurrence rate of CMEs is slightly increases towards Sunspots maxima and slightly decreases towards Sunspots minima. Fig 1. shows that the two largest peak in the CME rate, where as only one largest peak in SSN . CME rate is multiplied by fraction 30 to fit the scale. CMEs can occur at any time during the solar activity but their occurrence rate increases with solar activity and peaks around solar maximum. In the graph, the largest difference between CMEs occurrence rate and Sunspot number seems to be due to the fact that CMEs originate not only from the sunspot regions but also from non Sunspot (quiescent filament) regions. Based on the 110 Skylab CMEs, Hildner et al. [5] found the CME rate (R) to be corrected with the Sunspots number (n) and obtained the relation, R=0.96+0.084N (based on 7 rotations). They suggested that this relation is independent of the phase of the solar activity cycle and predicted a rate 3.2 per day for solar maxima. With new observation from Solwind and SMM/cp coronagraph, this relation was essentially confirmed [7]. Webb [8] studied CMEs from 1973 to 1989 concluding that (1) The frequency occurrence tends to follow the solar activity cycle in both amplitude and phase. (2) Considering only long term average all solar activity indices are equally correlated with CME rate. In our study we find out that the regression line is (23.43x-0.67) and correlation coefficient (r=0.75), which measure the degree linearly related. There is perfect relationship rate with positive slope between Sunspots number and CMEs occurrence rate ,as shown in correlation graph of Fig.2 .

IV. ACKNOWLEDGEMENTS

We thank to various world data centers for providing the data. Financial support in form of visit of the PKS to IUCAA, Pune as associate is thankfully acknowledged.

REFERENCES

[1] Hundhausen A J , J Geophys Res, 98 (1993)13177.
[2] Raychaudhuri P , Proc. 29 Thn ICRC, Pune, 1 (2005) 153.
[3] Newkirk G Jr, Hundhausen A J and Pizzo V , J. Geophys. Res., (USA) 86(A7) (1981) 5387.
[4] Wanger W A, Ann Rev Astron Astrophys, 22 (1984) 267.
[5] Hildner E et al. Solar Physics, 48 (1976) 127.
[6] Tousey R., Howard R A, Koomen M J, Bull. American Astron. (USA) SOC., 6 (1974) 295.
[7] Gopalswamy N, Yashiro S , Michalek G , Kaiser M L , Howard R A ,Reames D V , Leske R and Von Rosenvinge T , Astrophysica Journal, 572 (2002) 103.
[8] Webb D F, Advance in space research (UK) 11 (1) (1991) 37.