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Coronal mass ejections and sunspot number over solar cycle 24

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Abstract
In this article we work with the coronal mass ejections (CMEs) and sun spot number (SSN) during solar cycle 24 i.e. from 2008-2019. We have to take in to considerations that the CMEs have velocity >= 500 km/s and acceleration ~2000m/sec^2. To see the relation between these parameters we have extract the SSN from Sunspot Index and Long-term Solar Observations (SILSO), while CMEs number observations made by the Large Angle and Spectrometric Coronagraph (LASCO) on board the Solar and Heliospheric Observatory mission (SOHO). We have observed 1290 total CMEs for the current period. Out of these the rate of halo CMEs and partial halo CMEs are 35.34% and 64.65% respectively. The SSN are 132 for the current period. To conduct the investigation between CMEs and SSN we have performed statistical investigation between these parameters. To perform the statistical investigation taken the monthly averaged value of CMEs velocity and average value of SSN. The analysis of the results indicated that CMEs of different categories have mutual correlation with SSN. The correlation coefficients of halo and partial halo CMEs with SSN are 0.43 and 0.42 respectively.
Keywords: - Coronal mass ejections, Sunspot number, halo CMEs, Partial halo CMEs, Solar cycle.

1. Introduction

Coronal mass ejections (CMEs) consist of large structures containing plasma and magnetic fields that are expelled from the Sun into the heliosphere. They are of interest for both scientific and technological reasons. Scientifically they are of most interest because they remove built-up magnetic energy and plasma from the solar corona (Low, 1996), and technologically also they are of interest because they are responsible for the most extreme space weather effects at Earth (Baker et al., 2008), as well as at the other planets and spacecraft throughout the heliosphere.

A key parameter in the solar atmospheric phenomena is the solar cycle which takes approximately 11 years on average. During this time, the SSN starts from a minimal value and increases which marks the start of the solar cycle. Then, the SSN tends to reach a maximum, then decreases to a minimum value again which mark the end of a solar cycle. The reason for this phenomenon is believed to be the continuous fluctuation of the solar magnetic field, and this belief is strongly supported by the observed fact that a sunspot maintains a strong magnetic field.

The CME ejection occurrence rate was in good agreement with the sunspot area on the surface of the Sun than that with the sunspot numbers on the surface of the Sun. Conversely, spot area on the surface of the Sun is strongly linked with the sunspot numbers on the surface of the Sun. The sunspot numbers on the surface of the Sun and astrophysical change are in good link with coefficient value as 0.98. Year 2014, was the maximum solar flare year whereas solar year2009 and 2017 are the minimal solar flare year. Comparison of the yearly solar indices with sunspot number shows that mean value of the solar indices is minimal for 2009 with the respective values of 0.02 with the maximum indices value as 6.34 for the year 2014. Same behavior of occurrence is there smooth sunspot number and Dust storms with some contradiction due to the variation of Dust occurrence for moderate, intense, severe storms for the same year (Webb and Howard 2012).

Halo CMEs are so called because the excess brightness in these events appear to surround the occulting disk of the observing coronagraph as projected on the sky plane. Halo CMEs were discovered in Solwind images (Howard et al. 1982).

Sunspots assume as storms on the sun's surface that are marked by intense magnetic activity and play host to solar flares and gassy ejection from the sun's corona. Sunspots are very dark areas on the surface of the sun, formed when fluctuations in the sun's magnetic field bubble up to the surface. The spots are dark because they are cooler than the other parts of solar surface around them. Coolness of sunspots here is pretty relative a sunspot is still a piping hot an 8000 degrees Fahrenheit

(4500 Celsius), but it is surrounded by material that reaches temperature of 11000 degrees F (6000C) (Mcnish ans Lincoln 1949).
A sunspot is cooler and therefore darker regions of the sun's photosphere caused by solar magnetic disturbances. Strong dense solar magnetic field generated by circulating plasma sometimes become entangled and surge through the photosphere creating the sunspot (Hathaway et al. 1994).
The fact that the CME rate is correlated with sunspot number (SSN) reported from pre-SOHO coronagraphs (Webb and Howard 1994) was readily confirmed with SOHO CMEs for cycle 23 (Gopalswamy et al. 2003a). When the correlation was considered separately for the rise, maximum, and declining phases, it was found that the maximum phase had the weakest correlation (Gopalswamy et al. 2010a). The fact that (Gopalswamy et al. 2003b, 2003c) the number of CMEs associated with quiescent filament eruptions (i.e., non-spot) from the high and low latitudes increases during the maximum phase.
Gour et.al 2020 establish the relationship between CMEs and sunspot number by considering the CMEs having velocity greater than 500 km/s, they concluded that these two parameters are well correlated to each other but there is a moderate and weak correlation for some particular years of activity.
In this investigation depicts the changes in various solar parameters during the period from 2008 to 2019, which shows that in the starting of solar cycle 24, the Sun is quiet with low sunspot number and solar activity. The annually averaged numeral number of the sunspot on the surface of the Sun, for the time of 2008- 2019. In 2009, the numeral is 4.75 which ascend to the value of 113.63 in 2014 showing the maximal stage of the solar cycle. After that numeral value of the sunspot on the surface of the Sun descends for the minimal stage of the astrophysical period. In 2017, the sunspot numbers was 13.8.

2. Data Used

In this work we have extract the sunspot monthly mean value from Sunspot Index and Long-term Solar Observations (SILSO) http://www.sidc.be/silso/datafiles. The CME data used in this study is collected from LASCO and SOHO available in CME catalogue that can be found at https://cdaw.gsfc.nasa.gov/CME_list/index.html.

3. Result and Discussion

In this report we are investigating coronal mass ejections with sunspot spot number of solar cycle 24. We have found two types of CMEs are used in this investigation first one is Halo CMEs and partial Halo CMEs. Partial halo CMEs have an apparent width of 120°<- w<-360° and Halo CMEs have an apparent width of 360°. To obtain the relation between these parameters we have to take the data of CMEs having velocity >=500 Km/s and acceleration ~2000m/sec^2.
In this work we have observed 1290 CMEs during 2008-2019 out of these 456 (35.34%) are halo CMEs and 834 (64.65%) are partial halo CMEs. The monthly mean value of sunspot number was observed and the total sunspot numbers are 132 in the present study. Further report a statistical study for the relationship between coronal mass ejections (CMEs) and sunspot number (SSN) that were registered during the period 2008-2019 for the solar cycle 24.

3.1 Halo CMEs and Sunspot Number

Halo Coronal mass ejections (CMEs) data also extracted from CDAW data centre having velocity >= 500 Km/s and sunspot number from SISLO data centre. We have found 456 halo CMEs during this time period. Further we observed that Halo CMEs and sunspot number are correlated to each other with moderate positive correlation with correlation coefficient 0.43. To show the relationship between these parameters draw a scatter plot shown in figure-1.

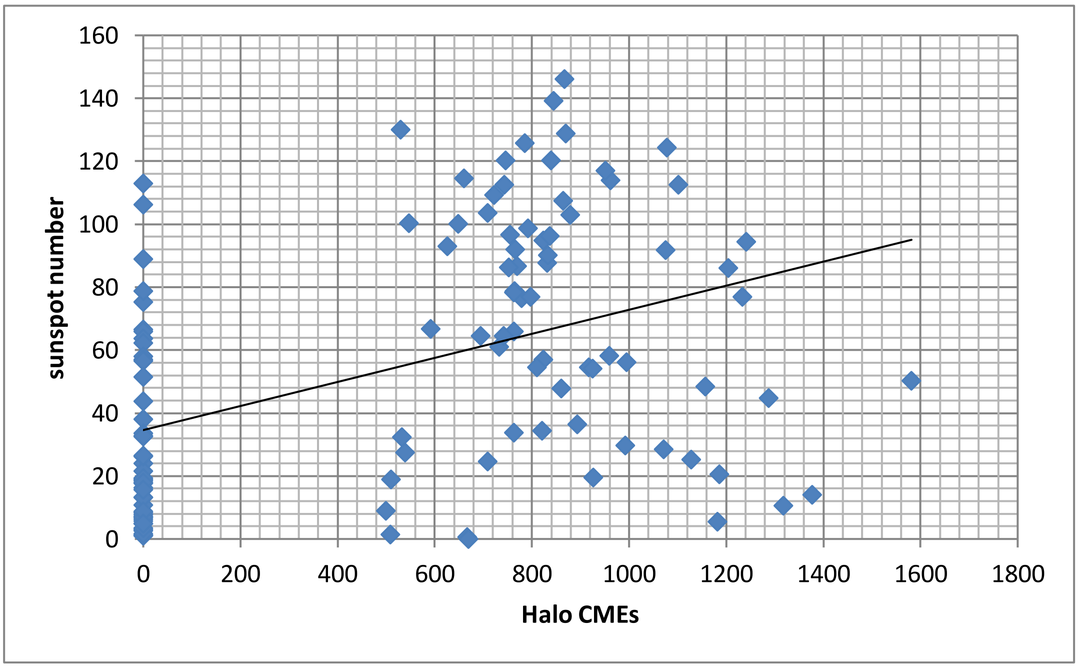

Figure-1 Scatter plot between halo CMEs and sunspot number showing correlation coefficient 0.43.

3.2 Partial Halo CMEs and Sunspot Number

We have extract monthly mean value of partial halo CMEs having velocity >= 500 Km/s from CDAW data centre and sunspot monthly average value form SISLO data centre from 2008-2019. We have found 834 partial halo CMEs for this period and 132 sunspot numbers. Further we obtain the correlation between partial halo CMEs and sunspot number by using statistical correlation coefficient of Karl Pearson's ,these parameters are moderately correlated to each other with positive correlation coefficient of 0.42. To show the relationship between these parameters draw a scatter plot shown in figure-2.

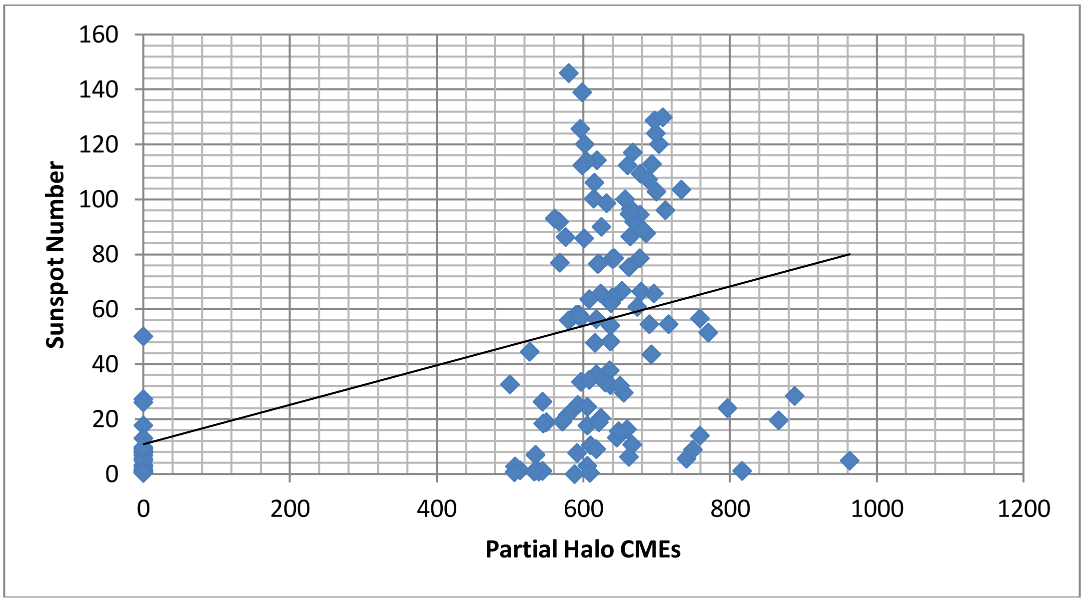

Figure-2 Scatter plot between partial halo CMEs and sunspot number showing correlation coefficient 0.42.

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References

i. Baker, D.N., Balstad, R., Bodeau, J.M., Cameron, E., Fennell, J.F., Fisher, G.M., Forbes, K.F., Kintner, P.L., Leffler, L.G., Lewis, W.S., Reagan, J.B., Small III, A.A., Stansell, T.A., Strachan Jr, L., Graham, S.J., Fisher, T.M., Swisher, V. and Gruber, C.A. (2008). *Severe Space Weather Events - Understanding Societal and Economic Impacts: A Workshop Report*, The National Academies Press, Washington DC.

ii. Gopalswamy, N. (2016). History and development of coronal mass ejections as a key player in solar terrestrial relationship. *Geosci. Lett.*, 3, 8. https://doi.org/10.1186/s40562-016-0039-2

iii. Gopalswamy, N., Akiyama, S., Yashiro, S., Mäkelä, P. (2010a). Coronal mass ejections from sunspot and non-sunspot regions. In: Hasan SS, Rutten RJ (eds) Magnetic Coupling Between the Interior and Atmosphere of the Sun. Astrophysics and Space Science Proceedings, Springer, Berlin, pp 289–307.

iv. Gopalswamy, N., Lara, A., Yashiro, S., Howard, R.A. (2003c). Coronal mass ejections and solar polarity reversal. *ApJ*, 598:L63–L66.

v. Gopalswamy, N., Lara, A., Yashiro, S., Nunes, S., Howard, R.A. (2003a). Coronal mass ejection activity during solar cycle 23. In: Wilson A (ed) Solar variability as an input to the Earth's environment. International Solar Cycle Studies (ISCS) Symposium, 23–28 June 2003, Tatranská Lomnica, Slovak Republic, ESA SP-535. ESA Publications Division, Noordwijk, pp 403–414.

vi. Gopalswamy, N., Shimojo, M., Lu, W., Yashiro, S., Shibasaki, K., Howard, R.A. (2003b). Prominence eruptions and coronal mass ejection: a statistical study using microwave observations. *ApJ*, 586:562–578.

vii. Gour, P.S., Joshi, H., Soni, S. (2020). Relation of sun spot number with coronal mass ejections. *Int J Innovat Res Growth*, 9, 92-96.

viii. Hathaway, D.H., Wilson, R.M., Reichmann, J.E. (1994). The shape of the sunspot cycle. *Solar Phys.*,151,177-190.

ix. Howard, R. A., Michels, D.J., Sheeley, N.R. Jr, Koomen, M.J. (1982). The observation of a coronal transient directed at earth. *ApJ*, 263:L101–L104.

x. Hussein, Z. F. (2019). Relation between Coronal Mass Ejections and Sunspot Number during Solar Cycle 24. *Iraqi Journal of Science*, 60, 1860-1867.

xi. Low, B.C. (1996). Solar activity and the corona. *Solar Phys.*, 167, 217–265.

xii. Mcnish, A.G., Lincoln, J.V. (1949). Prediction of sunspot number. *Eos Trans*, 30, 673-685.
xiii. Singh, A., Patel, K. (2021). Statistical Study of Solar Activity Parameters of Solar Cycle 24. *Journal of scientific research*, 65, 197-200.
xiv. Webb, D.F., Howard, R. (1994). The solar cycle variation of coronal mass ejections and the solar wind mass flux. *JGR*, 99, 4201–4220.
xv. Webb, D.F., Howard, T.A. (2012). Coronal Mass Ejections: Observations. Living Rev. Sol. Phys., 9, 3.