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CERTIFICATE

This is to certify that Mr./Ms./Dr./Prof. ....Dr. A. Iren Sobia.................... Asst. Prof.................... affiliated to ....Muslim Arts College............................ has participated/ presented paper in National Seminar On Functional Materials And Its Applications (NSFMA –2022), organized by the Department of Physics & Research Centre on 14th October 2022 at Muslim Arts College, Thiruvithancode, Kanyakumari District.

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Variation of Solar Activity during Solar Cycle 24

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Abstract

In this study the sunspot area (SSA), sunspot number (SSN), and coronal mass ejection (CME) measured characteristics during solar cycle 24 to look for possible parallels in their variable patterns. In general, the majority of the CME parameters, such as frequency of occurrence, angular width, speed parameters, mass, estimated force, and kinetic energy, increase or decrease in value as the number and area of sunspots change. We saw a peak-dip-peak pattern (the double-hump pattern) in the SSN and SSA between 2013 and 2014; a similar double-humped pattern was also seen in most of the CME parameters, but it appeared later. By dividing the solar cycle into periods of increasing solar activity which we termed the ascending phase; 2009 to 2014 and decreasing solar activity which we termed the descending phase 2015 to 2019 to determine that the correlation between some coronal mass ejection and sunspot parameters differs during the ascending and descending phases.

Introduction

The sun is a vigorous star and changes on time scales extend from minutes to billion of years. The solar atmosphere is one of the richest and most dynamic environments studied in modern astrophysics. Like earth, the sun has seasons. More precisely, it has a cycle that lasts about 11 years. The number of sunspots rises and falls and rises again in about 11 years. This is due to the variability of solar magnetic field. The variability of the magnetic field has a strong influence on the dynamics of the outer layer of the sun and is registered by several solar parameters such as the sunspot number and CME occurrence (Aradhna *et al.*, 2013)

The sunspots are the most easily observed and have been tracked since around early 1600s by Galileo..The sunspots can come into view as solitary, remote dark central region covered by a regular less dark region around umbra (Spiegel, 1994). Since last four hundred years, the periodic changes in the Sun's activity were featured with smoothed sunspot numbers that was brought into existence with its classification (Kunzel, 1961). The number predicts short term periodic high and low activity of the Sun. The part of the cycle with low sunspot activity is referred to as "solar minimum" while region with maximum solar activity is called as "solar maximum". Hathaway *et al.*, (2002) examined the 'group' sunspot number which shows it use in featuring the Sun's performance during the solar year (Hoyt & Schatten, 1998a). The solar activity parameter variability from one cycle to the next and geomagnetic records shows the difficulty in making empirical predictions of both types of activity. In the present work, we have analyzed in the solar cycle 24, which has its beginning in December 2008 and the cycle is ended in December 2019.

Coronal mass ejections (CMEs) are the explosions in the solar corona during its high magnetic conditions. CMEs from the solar corona are the most spectacular phenomena of solar activity and perhaps the primary driver and source of space weather (Gosling, 1997; Singh *et al.*, 2010). Traditionally, the coronal mass ejection ejects away around 10^{10}-10^{17}g of the core which gives out the energy of the order (~10^{19} – 10^{25} J) (Chen, 2011; Howard *et al.*, 1985; Vourlidas *et al.*, 2002). In this context, to examine here the observed characteristics of CMEs such as angular width, linear speed, final speed, speed at radius as 20 times as the solar radius, acceleration, estimated force (F) estimated from the observed mass and absolute acceleration reported by Gopalswamy *et al* 2007; It should be noted that

CMEs believed to originate from the solar active regions. 52–54 are subjected to propelling and retarding force leading to changes in speed, kinetic energy and position angles in as association with the sunspot area both in the Southern and Northern Hemispheres and sunspot numbers.(Gosling JT *et al* 1976, Sheeley NR *et al* 1999; Gopalswamy N *et al* 2009)

Data Analysis

The CME data used in this study is collected from the Large Angle and Spectrometric Coronagraph (LASCO) onboard the Solar and Heliospheric Observatory (SOHO) available in CME catalogue that can be found at http://cdaw.gsfc.NASA.gov/CME. The catalogue contains the observed CME parameters including Angular Width (AW is the angular measure of the size of the CME in the LASCO image) in degrees, Linear Speed (LS) in km/s, Final Speed (FiS) in km/s, Speed at radius as 20 times as the solar radius (20R) in km/s, acceleration (A) in km/s 2 , Kinetic Energy (KE) in J and Position Angles (Central Position Angle/Meridian Position Angle– CPA/MPA; The MPA gives the position angle at which the height– time measurements are made; while the CPA is essentially used to distinguish CMEs appearing simultaneously in the LASCO field of view, thus ideally the CPA and MPA are the same) in degrees. We also calculated the estimated 'force' (F in N) from the observed mass and the absolute value of the observed acceleration.

Result and Discussion

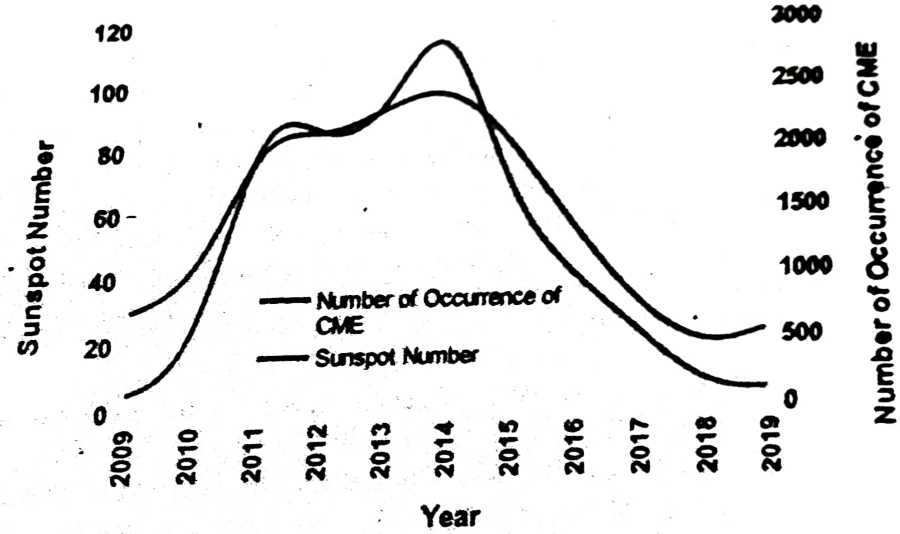

***Figure 1* The number of occurrence of CME per year (NOC), sunspot number (SSN).**

Fig(1) shows the comparative study of sunspot number and number of occurrence of CME of solar cycle 24.The activity of cycle 24 is depicts the yearly averaged numeral number of the sunspot on the surface of the sun, for year 2014 the maximum value is 113. After the year of 2014 the activity is declining towards at end of the cycle. Also shows the number of yearly occurrence of coronal mass ejection (CME) events in SOHO and LASCO directory. In 24^th^ cycle the plot showed an increase from about 745 CME events in the year 2009 to a maximum in about 2171 to 2475 CME events between the year 2017 to 2019 slight dip in the year 2018, then a reduction from the peak values between 2012–2015.

The above table1 shows 24th solar cycle yearly data of sunspot area. The above table shows 24th solar cycle yearly data of sunspot number of occurrence of CME and solar area for southern hemisphere, northern hemisphere and and full disk. A peak was seen in 2014 for the total Sunspot Area (SSAT) time series plot, which was similar for the Southern Hemisphere sunspot area (SSASH).The trend in variance for the sunspot area in the Northern Hemisphere time series plot (SSANH) shows peaks in 2013 with a small dip in 2014 similar to the double-hump-peak-dip-peak reported by (Ramesh, 2008) & (Kilcik *et al.* 2016) with a continuous drop from 2015 to 2019.

Table 1 Yearly average values of the sunspot number (SSN), sunspot area Southern hemisphere (SSASH), northern hemisphere (SSANH) and total(SSAT).

YEAR	Number of Occurrence of CME	Sunspot Number	SSAT	SSASH	SSANH
2009	742	5	26.6	8.4	38.6
2010	1103	22	214.3	62.9	18.6
2011	1963	81	749.6	187.6	224.7
2012	2124	85	796.9	154.7	328.7
2013	2302	94	860.8	552.8	575.9
2014	2416	113	1252.2	1227.6	506.7
2015	2048	70	618.8	495.2	239.6
2016	1380	40	348.2	61	286.8
2017	783	22	258.5	54.2	254.8
2018	470	7	210.5	48.8	201.4
2019	539	4	150.3	15.3	158.7

In Table 2, the average yearly values of the CME parameters (MPA, AW, LS, FiS, 20R, A, M, FX and KE), and the total yearly number of occurrence of CME were shown. The difference between the yearly averages of 170.5-142.8 degrees, or around 27.7 degrees, indicating that the yearly average of the position angle is constant. The AW variation appears to indicate both an increase and a drop with changing solar activity, with the AW variation somewhat peaking in 2014 (see the overlay yearly average).

The speed parameters (LS, FiS, and 20R) appear to follow the annual variation in the number of sunspots, increasing from 2008 and generally reaching their peak in 2014 before gradually declining until 2019. The yearly averages ranges from 70.4 -75.3 deg (a difference of about 5 deg).The LS increasing towards the years 2012 -2014 at peak value 542 km/s in 2012 and then its decreasing gradually at the end of year 2017,slightly reaching a peak during the year 2014. The average yearly FiS ranged from 478.9 km/s to 467.5 km/s with a maximum value is 558.8 km/s and showed similarities to the trend in the variation of LS, once more with a modest peak in the year 2012 and 2014. The yearly average speed at 20R is 555.8 km/s, with a range of 490 to 477 km/s. The trend in its variation from the overlaid yearly variation shows that it increased steadily from 2008 to about the end of 2019, reached a peak, decreased slightly in early 2012, and reached a peak again around in the middle of 2014 before decreasing steadily toward the end of the solar cycle 24 in 2019

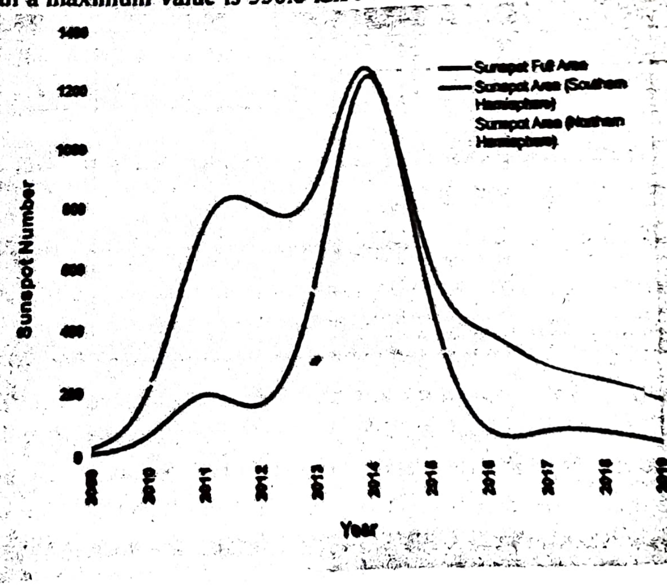

Figure 2 The yearly average time series plot of Sunspot Area (SSAT(Total)),SSANH (Northern Hemisphere) and SSASH (Southern Hemisphere)) for the solar cycle 24.

Figure2 the graph plotted yearly average time series plot between sunspot full area, SH, NH and year 2008 to 2019. In the graph the value of sunspot full area is maximum peak than the SSASH and SSANH. , the yearly averaged peak value of sunspot in full area is 1252.2 In SH the sunspot presented at the highest range of value be 1227.6. These two areas the sunspot is maximum in the year of 24th cycle is 2014, but the area of NH is maximum value is found in the year 2013 at the range of highest value be 575. From this graph to note the sunspot number is maximum in sunspot full area there is solar activity rising area in this solar cycle 24.

The fluctuation in acceleration appears to indicate that CMEs accelerate on average positively toward and during the solar minimum, but on average negatively toward the solar maximum. The yearly average of the acceleration appears to be more positive at the beginning and end of the solar cycle (when there is low solar activity), while it is more negative during the middle of the cycle (when there is greater solar activity). The general observation suggests masses and the estimated forces (F) of CMEs increase during the solar maximum but seem to decrease towards the solar minimum.

The yearly averages ranges from 70.4 -75.3 deg (a difference of about 5 deg).The LS increasing towards the years 2012 -2014 at peak value 542 km/s in 2012 and then its decreasing gradually at the end of year 2017, slightly reaching a peak during the year 2014.

Table 2 Yearly average values of the CME parameters–position angle (PA), angular width (AW), speed parameters (LS, FiS and 20R), acceleration (A) and mass (M), estimated force (F), kinetic energy (KE), NOC.

Year	No. of CME	MPA deg	AW deg	LS km/s	FiS km/s	20R km/s	A km/s	M(10^{14}) gram	F X (10^{12}) N	KE (10^{12}) ergs
2009	742	170.5	60.1	475.8	478.9	490.5	1.1	9.2	10.12	10.5
2010	1103	168.4	68.5	481.3	490.2	491.2	2.8	15.8	44.24	19.8
2011	1963	167.3	70.4	421.9	432.2	434.4	1.8	24.8	44.64	80.5
2012	2124	166.4	74.5	542.3	558.8	553.7	2.1	15.8	33.18	45.2
2013	2302	162.1	69.8	502.3	499.5	507.7	2.8	20.5	57.4	58.3
2014	2416	159.1	75.3	540.1	558.3	555.8	0.8	23.5	18.8	84.1
2015	2048	155.2	63.5	457.9	470.1	478.9	6.7	28.3	189.61	74.1
2016	1380	145.7	74.2	412.3	420.3	422.8	4.8	40.9	196.32	129.4
2017	783	142.8	67.9	389.4	374.2	388.3	7.8	7.9	61.62	58.2
2018	470	137.1	61.7	419.5	402.8	440.1	5.5	8.5	46.75	16.7
2019	539	124.9	65.3	457.6	467.5	477.4	8.9	7.4	65.86	11.8

Correlation coefficient of CME parameters verse sunspot number (SSN) and sunspot area (SA) verse sunspot number.

It is interesting to note that the CME rate and the SSN show a year correlation during maximum phase of the solar cycle (Gopalswamy *et al.*, 2009). This was explained in terms of the contamination of CME parameters rate with the population of CMEs associated with high values. During solar maximum, between the CME rate and the sunspot number though both of them show unambiguous double-humped pattern. The trends in the variations of CME parameters (CPA/MPA, AW, LS, FiS 20R, M, A, F and KE) with SSN, SSAT and SSANH/SSASH for correlation with sunspot. The correlation coefficients are reported (r is the correlation coefficient and here is merely used to illustrate the differences in the the varying CME/Sunspot parameters in the ascending and descending phases).Clearly, there is no association between CPA and MPA. Sunspot parameters (SSN, SSAT, and other CME parameters) and SSANH and SSASH), and the correlation is identical for each additional CME and sunspot characteristics for the relationship between CPA/MPA both the ascending and descending phases during the entire solar cycle, the is 0.59. The relationship between the LS and FiS speed parameters with SSN is 0.61 and 0.64. CME M, F, KE get a correlation values as 0.51,Force is negatively with a value -0.02, kinetic Energy is 0.54 and the sunspot parameters appear to be stronger in (and 20R) than during the ascending phase (period of declining) phase (time of increased solar activity) (period of increasing solar activity). AW also correlates with SSN, positively with A, but adversely while in the falling phase the value is 0.70. The sunspot area correlation coefficient with sunspot number is find in the solar cycle 24 .yearly correlation of SSAT value is high than other two that is 0.97, SSANH value is 0.76 and also SSASH is 0.82. The values of the correlation results seem to indicate that the correlation is stronger during the descending phase than during the ascending phase for the sunspot parameters SSN, SSAT, SSANH and SSASH.

CONCLUSION

To looked at the patterns of change in coronal mass ejection. (CPA/MPA, AW, LS, FiS, A, M, and F) observational parameters and KE), the sunspot number (SSN), and the overall area of the sunspots (SSAT), Northern Hemisphere sunspot area (SSANH) and sunspot area for the solar cycle 23 (SSASH) in the Southern Hemisphere using the analysis.

The Number of occurrence of CME (NOC) per year increases or decreases with increase or decrease in SSN/SSAT, but the variations is different. Every year, more CMEs (NOCs) occur unique. SSASH often has greater standards than SSANH. The NOC high around 2014 had a decline, which also happened not in SSASH but in SSANH. We generally found a peak-dip-peak pattern in SSN and SSAT, which also appears in a few CME parameters (AW), LS, FiS, 20R, and somewhat M, but with SSN/SSAT's taking place earlier. Between 2012 and 2014, when the solar activity increases, F and KE have high values, but with several peaks and dips. The correlations between AW and the other CME parameters (LS, FiS, 20R, A, M, F, and KE) with the sunspot parameters (SSN, SSAT, SSANH and SSASH) appear to be stronger during the descending phase (DES) than the ascending phase (ASC). For A and M, the correlations between them and the other parameters appear to be stronger during the descending phase than during ascending phase; but there was difference in F and KE. The CME speed and the correlation are both identical with the exception of AW, the other CME parameters, and parameters of the ascending and descending sunspots phase all the sunspot parameters. Finally, the results of the CME and sunspot parameters show trends for the solar cycle 24's high solar activity, but the variation vary in both strength and period for CME and sunspot characteristics showed strong correlations with each other but seems stronger during the ascending phase than descending phase and variety. The majority of CME characteristics often display a delay when they reach their maximum, including sunspot parameters.

REFERENCE

[1] *Sharma A; and Verma S.R (2013), Solar Activity during the Rising phase of Solar Cycle 24. International journal of Astronomy and Astrophysics, 3(3), 212-216.*

[2] *Hathaway, D. H., Wilson, R. M., Reichmann, E. J. (2002). Group Sunspot Numbers: Sunspot Cycle Characteristics. Solar Physics, 211, 357–370.*

[3] *Hoyt, D.V., and Schatten, K.H. (1998a). Group Sunspot Numbers: A New Solar Activity Reconstruction. Solar Physics, 179, 189–219.*

[4] *Gosling, J. T. (1997). Coronal Mass Ejections : An Overview, Geophysical Monograph Series, 99, 9-16.*

[5] *Singh, A.K., Siingh, D., Singh, R.P. (2010). Space Weather: Physics, Effects and Predictability. Surveys in Geophysics, 31, 581-638.*

[6] *Spiegel E. A. (1994). In Lectures on Solar and Planetary Dynamos, In: Proctor MRE, Gilbert AD, editors. UK: Cambridge University Press, 245.*

[7] *Kunzel, H. (1961) M. Waldmeier: The sunspot activity in the years 1610-1960. Zürich 1961: Verlag Schulthess u. Co. AG*

[8] *Howard, R. A., Sheeley, N. R., Koomen, M. J., Michels, D. J. (1985). Coronal mass ejections; Journal of GeophysicalResearch, 90, A9, 8173-8191.*