DEPARTMENT OF PHYSICS
ST. XAVIER'S COLLEGE (AUTONOMOUS)

Recognized as "College with Potential for Excellence" by UGC &
Accredited by NAAC at "A" Grade with a CGPA of 3.66 out of 4 in IV Cycle
Palayamkottai - 627 002, Tamil Nadu, INDIA

ICEMA 2022

INTERNATIONAL CONFERENCE ON
"EMERGING MATERIALS AND ITS APPLICATIONS" (ICEMA-2022)

Certificate

This is to certify that ~~Dr./Mr.~~/Ms. A. Iren Sobia of Muslim Arts College, Thiruvithancode has ~~participated~~ / presented a paper in the International Conference on Emerging Materials and It's Applications (ICEMA - 2022) organized by the Department of Physics, St.Xavier's College (Autonomous), Palayamkottai-627002 on 01 March 2022

Mode of Presentation Oral / ~~Poster~~

Title Variation of Solar Wind Parameters Observed By Stereo Spacecraft

Dr. B. Helina Dr. S. Anna Venus
Organizing Secretaries

Dr. D. Prem Anand
Head & Convenor

Rev. Dr. S. Mariadoss, S.J.,
Principal

INTERNATIONAL CONFERENCE
ON
"EMERGING MATERIALS AND ITS APPLICATIONS"
1st March 2022

CONFERENCE PROCEEDINGS: ICEMA-2022

CONVENER
Dr. D. Prem Anand
Head of the Department

ORGANISING SECRETARIES
Dr. B. Helina **Dr. S. Anna Venus**

PUBLISHED BY
DEPARTMENT OF PHYSICS
ST. XAVIER'S COLLEGE
(AUTONOMOUS)
Recognized as "College with Potential for Excellence" by UGC
Accredited by NAAC at "A++" Grade with a CGPA of 3.66 out of 4 in IV Cycle
PALAYAMKOTTAI - 627 002
TAMIL NADU, INDIA
Website: www.stxavierstn.edu.in

INTERNATIONAL CONFERENCE

ON

EMERGING MATERIALS AND ITS APPLICATIONS

CONFERENCE PROCEEDINGS : ICEMA -2022

CONVENER

DR. D. PREM ANAND

Head of the Department

ORGANISING SECRETARIES

Dr. B. HELINA **Dr. S. ANNA VENUS**

PUBLISHED BY

DEPARTMENT OF PHYSICS

ST. XAVIER'S COLLEGE (AUTONOMOUS)

PALAYAMKOTTAI – 627002

TAMIL NADU, INDIA

PERIODICITIES IN SUNSPOT ACTIVITIES DURING THE MAXIMUMPHASE OF SOLAR CYCLE 24

Mariya Shaniya. S[1], Iren Sobia. A[2]

[1]Research Scholar, Department of Physics and Research Centre, Muslim Arts College, Thiruvithancode

[2]Assistant Professor, Department of Physics and Research Centre, Muslim Arts College, Thiruvithancode

Shaniyashanu8997@gmail.com, irensobia@gmail.com

Abstract

In the present study, the short-term periodicities in the daily data of the sunspot numbers and sunspot areas are investigated separately for the full disk, northern hemisphere and southern hemispheres during Maximum Phase of Solar Cycle 24 for a time interval from 2011 to 2015 (1 January 2011 to 31 December 2015). The Morelet wavelet spectrum technique exhibited a number of quasi-periodic oscillations in all the datasets. In the high frequency range, we find a prominent period of 20 – 45 days and 40 – 50 days in both sunspot indicators. Other quasi-periods in the range of 16 – 25, 45– 70, 70 – 100, 120 - 125 and 140 – 240 days are detected in the sunspot number time series in northern hemisphere at different time interval and he range of 22 - 35, 70 - 75, 90 - 180and 110 – 180 days are detected in the sunspot number time series in southern hemisphere at different time interval. In the sunspot area data, quasi-periods in the range of 15 – 45, 13 – 45, 20 – 30, 50 – 60, 50 – 95, 45 – 100 and 110 - 150 days were noted in northern hemisphere and the range of 11- 60, 15 -22, 46 -150, 60 – 120 and 170 – 180 days were noted in southern hemisphere within the time period of analysis.

Keywords: wavelet spectrum, sunspot number, sunspot area

1. Introduction

The Sun is a dynamic star and changes on time scales ranging from minutes to billions of years. The near 153-day periodicity was first detected in γ -ray and X-ray flare rates (Dennis, 1985) recorded by the Solar Maximum Mission (SMM) and Geosynchronous Operational Environmental Satellites (GOES) in Solar Cycle 21. During the same solar cycle, a periodicity of 150 – 160 days was also found in various solar flare and energetic particle data (Cane, Richardson and von Rosenvinge, 1998; Chowdhury and Ray, 2006; Chowdhury, Ray and Ray, 2008). In the long-term, the Sun exhibits a nearly 11-year sunspot cycle (Schwabe cycle) and for short-term variations the 27-day periodicity is the most prominent (Watari, 1996). The regime between these extremes of time scales (27 days and 11 years) is known as the "midrange" (Bai, 2003). Several authors investigated the "midterm" periodicities of the sunspot data during Solar Cycles 12 through 23 (Atac, Özgüc, and Rybak, 2006; Joshi, Pant and Manoharan, 2006). Most of these studies revealed the existence of about a 152-day periodicity in Solar Cycle 21 and also in the rising branch of Solar Cycle 23. Carbonell and Ballester (1992) showed that the periodicity of 150 – 160 days was significant during all the Solar Cycles from 16 to 21, while the presence of this periodicity in Solar Cycle 22 is debatable (Bai, 2003). In addition, some other periodic and quasi-periodic components in different solar activity indicators were reported, such as the 51-day period (Bai, 1994), the 73-day period (Atac and Özgüc, 2006), the 86-day period (Joshi, Pant and Manoharan, 2006), Solar Cycle 24 started in December 2008 and attained maximum during July through August 2012.

2. Data and Analysis Method

Observational Data

The daily sunspot numbers in the whole solar disk, northern, and southern hemispheres of the Sun were published by the Solar Influences Data Analysis Centre (http://sidc.oma.be/sunspot- data/), a solar physics research division of the Royal Observatory of Belgium. The daily corrected data of sunspot area (expressed in units of millionths of the solar hemisphere) for the whole diskand both hemispheres used in this study are measured and compiled by the Marshall Space Flight Center of the U.S. Air Force/National Oceanic and Atmospheric Administration (USAF/NOAA) (http://solarscience.msfc.nasa.gov/greenwchs.html).

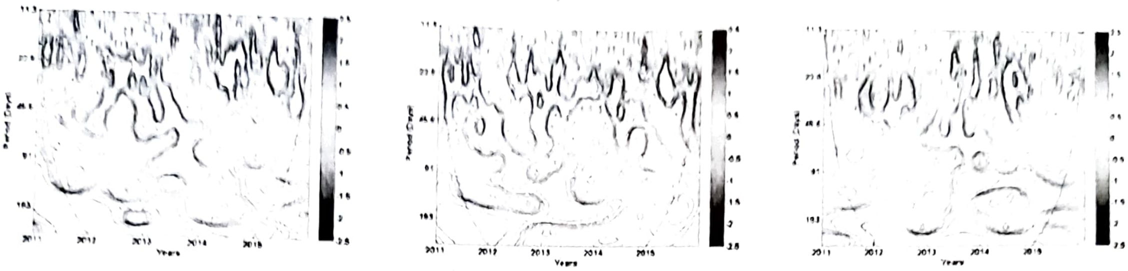


Figure 1: The wavelet power spectrum of the sunspot numbers of the full solar disk, northern and southern hemisphere.

3. Wavelet Spectrum and Evolution of Periodicities

We are interested in studying the temporal evolution of the short-term periods present in sunspot time series during the maximum Phase of Solar Cycle 24. Figures 1 through 6 depict the periodograms of the temporal evolution of the wavelet spectral power in daily sunspot numbers and areas.

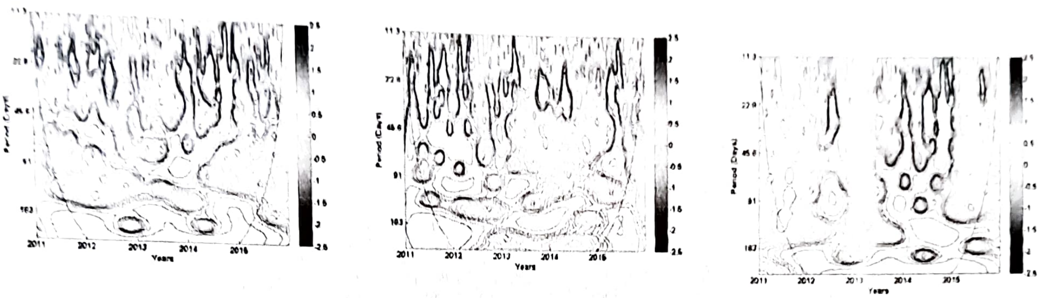
Periodicity in Sunspot Numbers

Figure 1 depicts the wavelet spectrum of the time series of daily sunspot numbers of the full disk, northern hemisphere and southern hemispheres during maximum Phase of Solar Cycle 24 fora time interval from 2011 to 2015. The period of 27 days corresponding to the solar rotation period is found prominent during the maximum Phase of Solar Cycle 24. However, the length of this period varies between 15 and 24 days. This period occurs during the year 2011. The period in the range of 20 – 45 days is found for a short span around the early of 2012, to the middle of 2013, from early 2014 to the end of 2015. Along with it quasi-periods of 40 – 50 days and 45 – 65 days occur in the time interval from June 2014 to March 2015 and from the middle of 2011 to early 2012, respectively. The period between 45 and 80 days is also detected from the year 2013 to the middle of 2014. A quasi-period in the range of 90 to 180 days appears in middle of 2014 and in the end of 2015. The period around 125 days is present from January 2013 to March 2014, but it is edge affected. Another intermediate-term periodicity with a varying length between 180 and 210 days appears in middle of 2012 to middle of 2013 and full year of 2014. Figure 2 represents the power spectrum of sunspot numbers for the northern hemisphere. In this figure we can observe that a short-term period in the range of 16 – 25 days is frequently present in all the years during the maximum phase. The period corresponding to the solar rotation with varying lengths between 20 – 45 days is found between February 2011 to early 2012. The period in the range of 40 – 50 days is also found between the middle of 2012 to the middle of 2013 and from May 2014 to early 2015, intermittently. A scattered period with a variable length between 45 – 70 days is frequently present in all the years during the maximum phase. Within the time interval from the early of 2012 to early of 2013, a prominent oscillation of 70 – 100 days is detected, but this period is slightly edge affected. The period lying between 120 – 125 days appears from the middle of 2014 to early 2015. A periodic signal of 140 – 180 days appears between January 2013 to 2015. The power spectrum of sunspot numbers in the southern hemisphere is given in Figure 3. A group of oscillations with a varying amplitude between 22 – 35 days appears from the middle of 2011 to the middle of 2012 and also from the middle of

ISBN NO : 978-81-956471-0-1

2013 to the end of 2014. The period between 40 – 50 days occurs in the middle of 2011 to the middle of 2012, and also from the middle of 2013 to the middle of 2014. A scattered peak of about 60 days is found intermittently for the spanof two year from the middle of 2012 to the middle of 2014. A 70 – 75-day periodic fluctuation is observed in end of 2012 for one year and also around the middle of 2013. Several other quasi- periods in the range of 90 – 180 days are detected around 2012 and during April 2013 to end of 2015. The best known "Rieger period" is also found present in the maximum phase of Solar Cycle 24 in this dataset. The period around 250 days is localized from the end of 2014 to the end of 2015, but this signal is slightly edge affected.

Figure 4,5 &6: The wavelet power spectrum of the sunspot areas of the whole solar disk, northern and southernhemisphere



3.1. Periodicity in Sunspot Area

The periodic behaviour of daily sunspot areas of the whole solar disk is shown in Figure 4. In this figure we can observe that a short-term period in the range of 16 – 25 days is frequently present in all the years during the maximum phase. A peak of about 11 days is noted in the end of 2014 for a short time span. The short-term periods including the Sun's rotational one between 16 – 40 days are found from early 2014 to early 2015, but it is edge affected. This signal reappears from the middle of 2015 to the end of 2015. An island of enhanced power in the range of 40 – 50 days is found from the middle of 2015 to early 2016. An intermittent power of 50 – 60 days appears in a different part of the intervals, from early 2012 to the end of 2014 and the middle of 2015 to the end of 2015. In late 2012 to middle of 2013, a period between 62 – 72 days occurs. Figure 4 indicates that signals of 80 – 180 days are present for a long time span around the early of 2011 and middle of2014 to end of 2015.Figure 5, which represents the power spectrum of the sunspot area time series for the northern hemisphere. An island of enhanced power in the span of 15 – 45 days with partially edge affected is detected from the January 2011 to April 2011. A 13 – 45-day oscillation during May 2011 to middle of 2012 is also detected. The Sun's synodic rotational period between 20 – 45 daysis found in late 2012 to early 2013 and the 20 – 30-day small peak appears for a small time interval in early late 2013 to middle of 2014..The periodicity with a variable amplitude between 10 – 64 days is detected between March 2015 and end of 2015. From the middle of 2012 to late 2012, the scattered contours with a variable period of 50 – 60 days and another period of 50 – 95 days are detected in early 2011. The wavelet algorithm enables us to locate the occurrence of the periods between 45 – 100 days from the middle of 2014 to middle of 2015 and it is edge affected on the right side. In the power spectrum, a peak of 110 – 150 days from middle of 2011 to early 2013 are also detected.

The power spectrum of the southern hemisphere sunspot area data is depicted in Figure 6. Variable periods, in the range of 20 – 45 days, are found within the interval from April 2012 to the June 2012. A periodic response of 11 – 60 days is seen from late 2013 to early 2015 and a scattered period of 15 – 22 days is also present in different phases in the middle of 2013 and the middle of 2015. A broad contour of 46 – 150 days is located from middle of 2013 to late 2014. The wavelet spectrum also shows the presence of the period of 60 – 120 days in early 2012 to late 2012.

4. Discussion

In this article, extensive time series analysis is done to detect the short-term periodicities in the range of 16 – 250 days for the daily data of sunspot number and area separately for the whole solar disk, northern, and southern hemispheres. Our study covers the entire maximum phase and a major portion of the minimum epoch of Solar Cycle 24. The power spectral analysis by the wavelet method reveals the existence of a number of short-term quasi-periodicities in the data of both sunspot numbers and areas. Figures 1 through 3 represent the existence of significant periods of 15 – 24, 24 – 35, 32 – 40, 40 – 50, 45 – 60, 70 – 75, 70- 100, 90 – 180, 110 – 110, 140 – 180 and 180 – 240 days in different epochs of the time series of daily sunspot numbers under study.

The power spectrum of daily sunspot areas for the maximum phase of Solar Cycle 24 is exhibited in Figures 4 through 6. The wavelet spectrum shows the presence of several significant short-term quasi-periodicities like 16 – 25, 20 – 45, 40 – 50, 62 – 72, 50 – 95, 45 – 100, 80 – 180 and 130 – 155 days. All these periods are found time variable with variable lengths. Nevertheless, the period between 24 – 35 days occurs prominently in the sunspot area time series during the minimum epoch of Solar Cycle 24, as seen in the daily sunspot numbers. This group of periodicities is found much more stable throughout the declining phase than the others.

Kiliç (2009) examined the high frequency fluctuations (16 – 40-day periodicity) in the sunspot number and area for the whole disk of the Sun separately over the rising, maximum, and the declining phases of Solar Cycle 23 (1996 – 2006). The author found significant peaks at 26.4, 29.5, 34.5, and 36.4 days in the daily sunspot number data and the periods of 26.4, 29.3, 34.5, and 36.4 days in the sunspot area during the descending phase of Solar Cycle 23. Bidhu et al., (2017) reported, 13.1 day, 27 day are common to the parameters like density, solar magnetic field, temperature and velocity during 24th solar maximum.

5. Conclusions

The comparison of periodogram analysis of three kinds of data sets during 1 January 2011 to 31 December 2015, presented in this paper, suggests that the results of sunspot numbers generally agree with the results of sunspot areas. The total sunspot numbers exhibit the highest peak near 180 - 240 days. Two other important periodicities of 20 – 45 days and 40 – 50 days in both sunspot indicators. Other quasi-periods in the range of 16 – 25, 45– 70, 70 – 100, 120 - 125 and 140 – 240 days are detected in the sunspot number time series in northern hemisphere at different time interval and he range of 22 - 35, 70 - 75, 90 - 180 and 110 – 180 days are detected in the sunspot number time series in southern hemisphere at different time interval. In the sunspot area data, quasi-periods in the range of 15 – 45, 13 – 45, 20 – 30, 50 – 60, 50 – 95, 45 – 100 and 110 - 150 days were noted in northern hemisphere and the range of 11- 60, 15 -22, 46 -150, 60 – 120 and 170 – 180 days were noted in southern hemisphere within the time period.

6. References

1. Atac, T., Özgüc, A.: Overview of the Solar Activity During Solar Cycle 23, *Solar Phys.*, 2006, 233,139.
2. Atac, T., Özgüc, A., Rybak, J. Periodicities in Irradiance and in other Solar Activity Indices During Cycle 23, *Solar Phys.*, 2006, 237, 433.
3. Bai, T.: Distribution of Flares on the Sun: Superactive Regions and Active Zones of 1980—1985,

Astrophys. J. , 1987, 314, 795.

4. Bai, T., The 51-day periodicity in cycle 22, *Solar Phys.*, 1994, 150, 385.
5. Bai, T., Periodicities in Solar Flare Occurrence: Analysis of Cycles 19-23, *Astrophys.*, *J*, 2003, 591,406.
6. Bidhu, SS, Iren Sobia A and Dickson Benjamin, Solar Wind Periodicities in 24 Solar Maximum, *Journal of Applied Geology and Geophysics*, 2017, 68-73.
7. Cane, H.V., Richardson, I.G., von Rosenvinge, T.T., Interplanetary magnetic field periodicity of ~153days, *Geophys. Res. Lett.*, 1998, 25, 4437.
8. Carbonell, M., Ballester, J.L., The periodic behaviour of solar activity-The near 155-day periodicityin sunspot areas, *Astron. Astrophys.*, 1992, 255,350.
9. Chowdhury, P., Ray, P.C., Periodicities of solar electron flare occurrence: analysis of cycles 21–23, *Mon. Not. Roy. Astron. Soc.*, 2006, 373, 1577.
10. Chowdhury, P., Ray, P.C., Ray, S.: *Ind. J. Phys.*, 2008, 82, 95.
11. Chowdhury, P., Khan, M., Ray, P.C.: 2009, Intermediate-term periodicities in relativistic solar electron fluences during solar cycles 22 and 23, *Adv. Space Res.*, 2009, 43, 297.
12. Dennis, B.R.: 1985, Solar hard X-ray bursts, *Solar Phys.*, 1985, 100, 465.
13. Joshi, B., Pant, P., Manoharan, P.K., Periodicities in sunspot activity during solar cycle 23, *Astron. Astrophys.*, 2006, 452, 647.
14. Kiliç, H., Midrange periodicities in sunspot numbers and flare index during solar cycle 23, *Astron. Astrophys.*, 2008, 481, 235.
15. Kiliç, H., Short-Term Periodicities in Sunspot Activity and Flare Index Data during Solar Cycle 23, *Solar Phys.*, 2009, 255, 155.
16. Watari, S., Separation of periodic, chaotic, and random components in solar activity, *Solar Phys.*, 1996, 168, 413.