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A Study on Midrange Periodicity of Sunspot Number during Solar Cycles 21, 22, 23 & 24

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Abstract- In this paper, we are going to explore the feasibility of periodicity of sunspot number activity during the solar cycles 21, 22, 23 & 24. The Sunspots are cooler and darker regions on the Sun's photosphere comparing to the surrounding regions. Sunspots usually appear in pairs. The two sunspots of a pair have different polarities, one would be a magnetic north and the other is a magnetic south, and can be joined by magnetic field lines. The number of sunspots that can be seen on the surface of sun increases and decreases in a regular pattern known as a solar cycle with a maximum number of sunspots occurring every 11.5 years. This paper shows the comparison between the midrange periodicity in sunspot number for four different cycles.

Index Terms- Sun, solar activity, sun spots number.

I-INTRODUCTION

The Sun is our nearest star and has been the subject of scientific and cultural discussion for thousands of years. Our ancestors realized that their lives depended upon the Sun and they held the Sun in reverent awe. It is an ordinary star - not particularly big or small, not particularly young or old. The Sun is the source of light and heat for life on Earth.

The sun is G2V star. It is composed of hydrogen and helium plasma of total mass of $1.9889*10^{30}$kg. The sun has two primary regions the solar interior and the solar exterior. The solar interior is separated into four regions by the different processes that occur in solar type star.fig. 1 is shows the innermost part is the core, where the energy is generated. This energy diffuses outward by radiation (mostly gamma-rays and x-rays) through the radiation zone and by convective fluid flows through the convection zone the outermost 30%.The portion we are able to see is the photosphere. Also there is a thin interface layer (the "tachocline") between the radiation zone and the convection zone is where the Sun's magnetic field is thought to be generated.

A. SOLAR ACTIVITY

It refers to any natural phenomena occurring on or in the Sun, such as: Sunspots, Solar flares, Solar wind, Coronal mass ejection etc. Solar activities treated for the present study are Sunspots. And in this paper we are studying sun spot number during the different cycles.

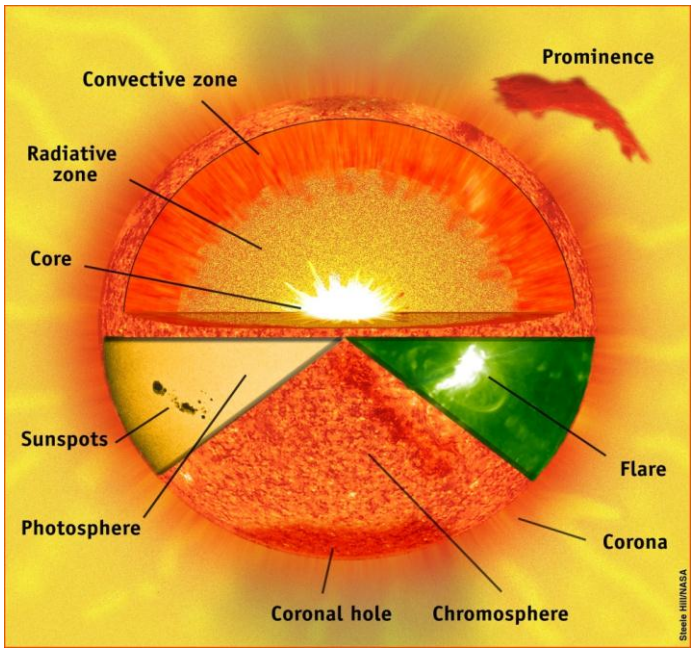

Figure.1 Cross-section of a solar-type star

B. SOLAR CYCLE

The sunspots are one of the strongest pieces of evidence for the *solar cycle* which describes a variation in solar activity over an 11 year period. The possibility of a solar cycle was first noticed in 1843 by Samuel Schwabe after counting the number of sunspots present on the Sun over 17 years. He noticed that the number of sunspots visible at any one time was not a constant, but rose and fell gradually over time. The number of sunspots that can be seen on the surface of sun increases and decreases in a regular pattern known as a solar cycle with a maximum number of sunspots occurring every 11 years. Solar variations cause changes in space weather and to some degree weather and climate on Earth. It causes a periodic change in the amount of irradiation from the sun. .

The **solar cycle** (or **solar magnetic activity cycle**) is the periodic change in the sun's activity (including changes in the levels of solar radiation and ejection of solar material) and appearance (visible in changes in the number of sunspots, flares, and other visible manifestations). Solar cycles have duration of about 11 years. They have been observed (by changes in the sun's appearance and by changes seen on Earth, such as auroras) for hundreds of years.

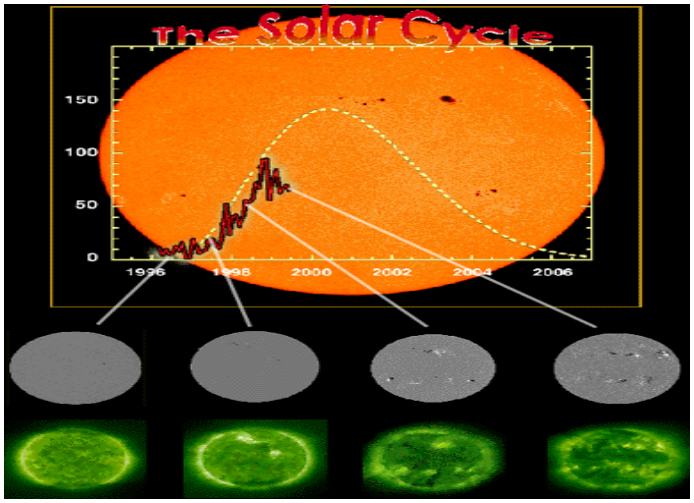

Figure-2: The Solar cycle

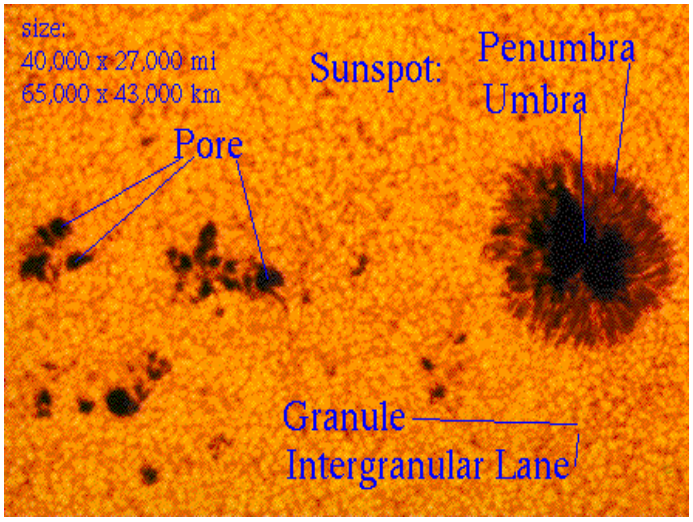

Figure-3: Sunspot

C. SOLAR CYCLES 21, 22, 23, 24

Solar cycle 21 was the 21st solar cycle since 1755, when recording of solar sunspot activity began. The solar cycle lasted 10.3 years, beginning in 1976 and ending in 1986. The maximum smoothed sunspot number (monthly number of sunspots averaged over a twelve month period) observed during the solar cycle was 164.5, and the minimum was 12.3.There were a total of 273 days with no sunspots during this cycle. Solar cycle 22 lasted 9.7 years, beginning in 1986 and ending in 1996. The maximum smoothed sunspot number observed during the solar cycle was 158.5, and the minimum was 8.There were a total of 309 days with no sunspots during this cycle

Solar cycle 23 lasted 12.6 years, beginning in 1996 and ending in 2008. The maximum smoothed sunspot number observed during the solar cycle was 120.8, and the minimum was 1.7. There were a total of 805 days with no sunspots during this cycle. Solar Cycle 24 is the current solar cycle, and began in 2008, but there was minimal activity through early 2009.

D. SUNSPOTS

Fig.-3 is showing that the Sunspots are cooler regions on the Sun's photosphere (about 1500 K cooler) and so appear to be darker than the photosphere. A given sunspot can have a lifetime ranging from a few hours to a few months. It consists of two parts - the dark inside region called the umbra and the surrounding less dark region.

Sunspots are temporary phenomena on the photosphere of the Sun that appear visibly as dark spots compared to surrounding regions. They are caused by intense magnetic activity, which inhibits convection by an effect comparable to the eddy current brake, forming areas of reduced surface temperature. Like magnets, they also have two poles.

II-METHODOLOGY

This study mainly focuses on periodicity of sunspot cycles. It tries to find out mid range periodicity of four solar cycles, cycle 21, 22,23 and 24 and also the relation connecting flare index and sunspot numbers.

I. Midrange periodicity

As a long term periodicity, sun exhibits 11 year sunspot cycle and for short term sun often exhibits 27 days periodicity which is attributed to the rotation of sun. The period between these extremes of time scales (27 days and 11 years) is called the ‘midrange ‘periodicity.

II-Midrange periodicity of cycles 21, 22 and 23

1. To find out the midrange periodicity of these cycles I made graph of monthly average of sunspot numbers versus month of each cycle separately in excel spread sheet.
2. Daily values of sunspot numbers for each cycle are tabulated and average of daily sunspot numbers of each cycle is found out.
3. Peaks above the obtained average value are identified from graph and differences between successive peaks are tabulated.
4. Then mean of the differences is found out.
5. Obtained mean multiplied by 30 gives the midrange periodicity in days.

III .Midrange periodicity of Cycle 24

Cycle 24 is going on now. Analysis for midrange periodicity of cycle 24 is made with some assumptions. For the analysis I extended the graph according to the data from year 2006 to 2012. As every cycle is following the same pattern and year 2012 is assumed as the peak of 24^{th} cycle, with the available data, I extended the graph for the declining phase as the same way it is increasing. Then the above procedure is followed for cycle 24 for finding its midrange periodicity.

III.RESULTS AND DISCUSSIONS

The graph [4] shows the difference between year and yearly mean of sunspot number from 1900 to 2012 (up to July 31) is shown below

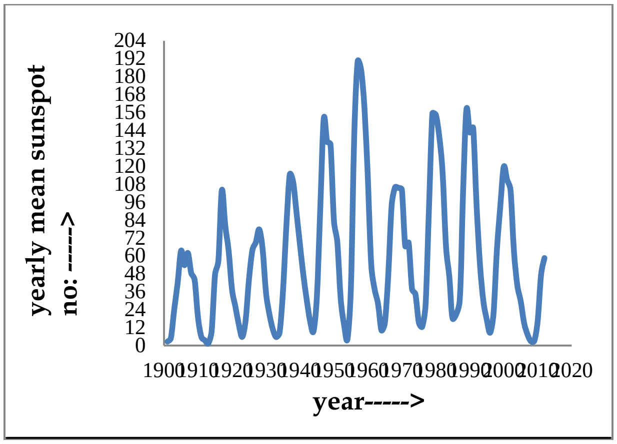

Figure.4: Graph between year and yearly mean sunspot number

From the plot it is very clear that the sunspot numbers are showing a regular pattern but maxima and minima's of different cycles are varying widely. The variations in maxima (63.5 and 190.2) of different cycles are more comparatively to the variations in minima's (1.4 and 17.9). Also from 1900 to 1960 the maxima of consecutive cycles shows an increasing pattern but after 1960 maxima of consecutive cycles following a decreasing pattern.

Table-1 showing the difference between peak values with respect to years is identified and it is as follows

Year	No: of years
1905-1917	12
1917-1928	11
1928-1937	9
1937-1947	10
1947-1957	10
1957-1968	11
1968-1979	11
1979-1989	10
1989-2000	11

Table-1The difference between peak values with respect to years

The difference between consecutive peak values from year 1900 to 2012is coming as **10.5** years. This shows good agreement with the 11 year solar cycle. Based on this result we can suggest that the maximum of cycle 24occurs towards the end of year 2012 or the beginning of 2013 and it is assumed that the cycle will be in the maximum phase now

A. CYCLE 24

Fig.-5 shows the 24^{th} solar cycle is going on now. The data from January 2006 is taken for study.

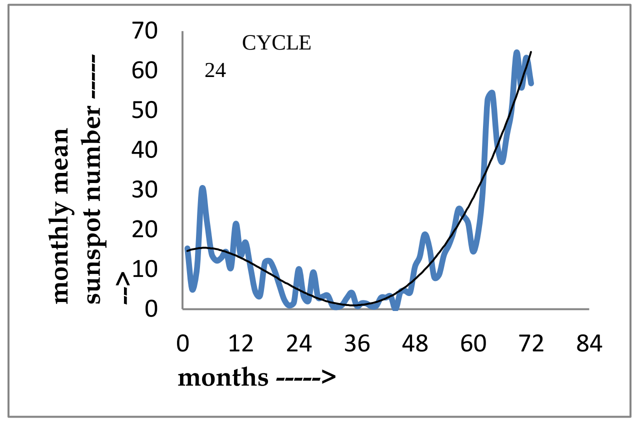

Figure.5: Graph of month vs monthly sunspot mean for cycle 24

The monthly average of sunspot numbers from January 2006 to December 2011 is obtained as 15. Average of successive peak values is4.58 months. Midrange periodicity of **137 ± 2** days is obtained.

B. CYCLE 23

Fig.-6 showing the data from January 1996 to December 2006 is taken for the study

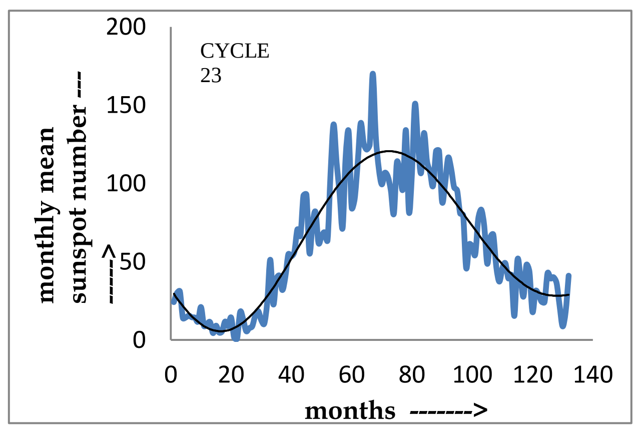

Fig.6: Graph of month vs monthly sunspot mean for cycle 23

The average of daily values of sunspot numbers from January 1996 to December 2006 is obtained as 60. Average of successive peak values is 3.57 months. Midrange periodicity of **107 ± 6** days is obtained.

C. CYCLE 22

Fig.-7 showing the data from January 1986 to December 1996 is taken for study. The average of daily values of sunspot numbers from January 1986 to December 1996 is obtained as 80. Average of successive peak values is 3.16 months. Midrange periodicity of**95 ± 8** days is obtained

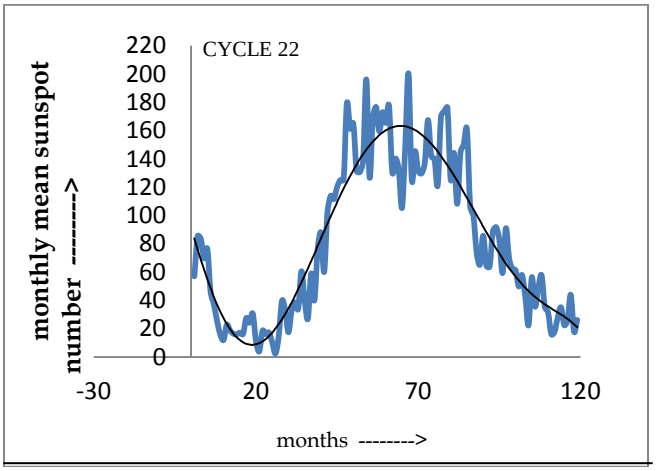

Fig.7: Graph of month vs. monthly sunspot mean for cycle 22

D. CYCLE 21

Fig.-8 showing the data from January 1976 to December 1986 is taken for study. The average of daily values of sunspot numbers from January 1976 to December 1986 is obtained as 78. Average of successive peak values is4.66 months. Midrange periodicity of **140 ± 8** days is obtained.

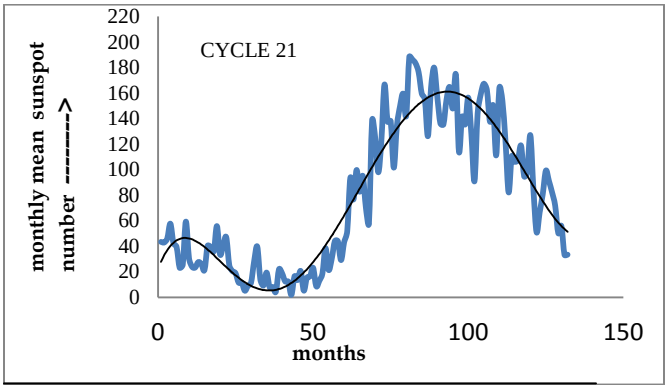

Fig.8: Graph of month Vs monthly sunspot mean for cycle 21

IV-CONCLUSION

In this paper, we analyzed the periodicity of the sun spot number and four different cycles are analyzed for midrange periodicity. Analysis of the data reveals that the existence of 11 year periodicity of sunspot cycle and midrange periodicities of 140 ± 8, 95 ± 8, 107 ± 6 and 137 ± 2 days exist in solar cycles 21, 22, 23 and 24 respectively.

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