

The Beauty of Solar Cycle-Do the Solar Cycles Follow the Fibonacci Sequence? A Possibility

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Abstract: Although the answer of the question- “Do the Solar Cycles follow the Fibonacci sequences?” is “No” till date, an attempt has been made in this study to find the plausible answer using approximation of rounding up the calculated values i.e. the ratio of total duration of solar cycle (SC) to the deviation of rise time and then compared with the available data of observed sunspots in each cycle of all the past 24 solar cycles. The significant findings of this study are: 1) The maximum number (> 285) of sunspots may be observed in that cycle when the deviation percentage of ratio is deviated following the Fibonacci number 3 (i.e. F_4) but approaches to the value 3; (2) The rounding up of the ratio follows the Fibonacci Numbers 1, 1, 2, 3, 5 i.e. the solar cycle follows the Fibonacci sequence up to $F_5 = 5$. (3) As it is considered the “approximation” (i.e. approximated value of the ratio of total duration / rise time through rounded up) for understanding the realistic scenario further more data from the future solar cycles are essential for which we have to wait for next solar cycles to be occurred in future. (4) Comparison with the mythological view of the sun (i.e. with the seven white horses) hints that solar cycle should have to follow Fibonacci sequence upto minimum number $F_7 = 13$. This means F_6 and F_7 still remain as mystery in solar cycles physics. The author, thus, encourages the Solar Cycle Research Community to look into this matter during their observations / investigations.

Keywords: solar cycle, sunspots, Fibonacci sequence, golden ratio

1. Introduction

“Fibonacci sequence is not just a pattern — it’s the living heartbeat of nature’s unfolding memory”

Beauty exists every-where in nature and it is associated with the Golden Ratio and Fibonacci Number (sequence). Looking back into the history of such idea usually comes from Greek art, sculpture and Mathematics. For example, Plato in his book [1] made an idea expressing that

- The geometric mean is the nature’s primary bond;
- Two things cannot be rightly put together without a third;
- There must be some bond of union between them;
- The fairest bond is that one which makes the most complete fusion of itself and the things which it combines;
- Proportion is the best adopted to reflect the effect of such union i.e. the golden is such required one that produces the simplest geometric mean of all.

This utter sublimity of the golden ratio can be further seen in almost all fields of sciences indicating that it is the (hidden) fundamental source of all beauty [2].

This includes

(i) **Golden Biology** → in particular the phyllotaxis i.e. the growth function of plants and patterns of leaf spacing on the stem. It is to be noted that the earlier observation of Leonardo Da Vinci (1452 – 1519) suggested that the spacing of leaves of plant was often spiral in arrangement while Johannes Kepler (1571 – 1630) proposed that the majority of wild flowers are pentagonal, and that Fibonacci number occur in leaf arrangement. Mystery arises in the phyllotaxis field on two discoveries in the 19th century when

(a) the Bravais brothers (in 1837) [3] invented the crystal lattice which is applicable as the ideal divergence angle of phyllotaxis: $137.5^\circ = 360 / \phi^2$. The significance of this special phyllotaxis is that this leaf arrangement offers a most effective and efficient arrangement for the plant in receiving maximum sunlight, moisture and pollination indicating an aesthetics based self efficiency of function in daily life.

(b) Another discovery was symmetry in plants when Jean and Barbabe [4] explained the emblems of phyllotaxis exhibited in Daisies and Sunflowers using the golden ratio i.e. the presence of particular numbers i.e. Fibonacci number, special angle 137.5° and the golden ratio $\phi = (1+\sqrt{5})/2 = 1.61803\dots$

(ii) **Golden Heart** → Like the presence of Fibonacci number, golden ratio and symmetry in plants these are also presence in human body and other mammals in their cardiac activity when the middle pressure in the aorta is considered as the measurement unit then the systolic blood pressure and the diastolic blood pressure approach to 0.382 ... and 0.618, respectively [5] implying that the ratio of these two measured blood pressure (i.e. $0.618 / 0.382 = 1.618\dots$) corresponds to the golden ratio. The significance is that although there is variation in the heart’s systolic (t_1) and diastolic (t_2) activity in two time intervals of different duration but there is an optimal (i.e. golden) frequency for human and other mammals when the duration of systolic, diastolic and the full cardiac cycle (T) follow the golden mean proportion i.e. $T / t_2 = t_2 / t_1$. This means that the cardiac performance in the timing cycles and blood pressure variations is optimized by following the golden mean ratio or proportion. In other words, it can be said that

“nature (or God) has constructed the heart in such a way that it performs its function with minimal expenditures of

energy, blood, muscle and vascular tissue exhibiting aesthetically optimal function”.

(iii) **Golden Cosmic Symphony**→ The known fact is that space has no crystalline structure but it does have gravitational fields and electromagnetic fields that permeating it. Our present understanding indicates that some kind of interaction of these fields with matter offers a situation whereby the solar system formation took place such that a close relationship to golden ratio are found to link every planet, harmonic and other periodic perturbations between planets and planet pairs. For example, the average deviation from the Fibonacci series for the eight planets plus two white dwarf planets orbits is 2.75 % [6, 7] (see table 1: showing the comparison of the Fibonacci series to orbits and synodic conjugations in ref. [7]) implying that comparison with the Bode's law [8] exhibits a 15% average deviation. This means that analysis of the Power Spectral Density, solar activity / cycles suggest that there is a link between planetary motion and solar activity levels.

Observations and studies of space weather though spacecrafts suggest that

- It is driven by the periodic variation of the magnetic field at and above the solar surface;
- The dynamo motions of plasma within the convection zone of the sun generate that magnetic field;
- “Active Region” are those regions where the magnetic field has erupted through the surface and then become organized / accumulated into the region;
- The sun's magnetic field increases and decreases in time with a polarity reversal every 11 year i.e. the strength of the solar magnetic field, in this cycle of magnetic field, varies from cycle to cycle in an irregular manner [9];
- This dynamo based solar cycle model hints that the polar magnetic field is a natural “predictor” of the following cycle;
- Considerable evidences indicate that the strong toroidal magnetic fields in this solar dynamo model manifest in the form of sunspots which is generated by the winding up of a weaker poloidal magnetic field with differential rotation [10];
- This windup, therefore, follows essentially a linear process such that the amplitude of a solar cycle is “expected” to be proportional to the amplitude of the poloidal field around the start of the cycle.

In this study I consider the available various parameters for the solar cycle no 1 (CS-1) to the solar cycle no-24 (CS-24) and attempt to answer the question- “Does the solar cycles follow the Fibonacci sequence for generating the highest number (>285) of sunspots in that cycle?”.

2. Solar Cycles, and Sunspots

2.1 Hindu (Indian) Mythological view

According to Hindu mythology [11] the “Sun God Surya” rides a golden chariot pulled by seven white horses. The symbolic representation and meaning theses seven horses as

- Days of the Week:** The seven horses stand for Sunday through Saturday, showing the continuous cycle of time.

- Colors of Light:** They represent the seven colors of the rainbow (VIBGYOR) and visible solar rays.



Figure 1: Sun God as Surya which is an advancing chariot pulled by seven white horses (courtesy: Wikipedia).

According to the Hindu Mythological view the solar cycle is viewed as (a) the visible manifestation of cosmic order, and (b) the eternal passage of time. (c) The sun is also personified as the deity Surya, as a celestial body the regulator of seasons and time cycles. This means that the sun covers both the mythology and the cosmology through a deep intertwined phase with the physical cycles of the natural world.

In the symbolic view (figure 1) [12] the sun is an advancing chariot, pulled by seven white horses i.e. like a living object. This means like other living objects, systems, the Fibonacci sequence is also applicable to the solar cycle activities. For example : the known facts are

- Specific Fibonacci numbers map precisely to the rotational lengths of sunspot cycles* — Helioseismological study reveals that when solar activity variations are measured, the timing of the approximate 11 year solar cycle can be splitted into consecutive Fibonacci integers [13]
- The sunspot cycle does not align with perfectly with our standard calendar year but calculation of highly statistical precision arise at:
 - The total cycle length ($F_{12} = 144$) → The recurring length of an entire sunspot cycle i.e. the most frequent overall duration of a full sunspot cycle is exactly 144 solar rotations which is the 12th Fibonacci number (i.e. $F_{12} = 144$). This translates closely to the observed ~ 11 Earth years.
 - The ascending leg ($F_{10} = 55$) → The ramp up phase i.e. from a quiet solar minimum to peak turbulence lasts 55 solar rotations.
 - The decending leg ($F_{11} = 89$) → The weakening phase of solar activity i.e. from solar maximum back down to minimum (on average value) lasts 89- solar rotation.

2.2 History of observation of solar cycle, sunspots

During the period 1761 – 1776 Astronomer Christian Horrebow [14] first idealized that the solar cycle is cyclic through the regular observations of sunspots from the

Rundetaarn Observatory, in Copenhagen, Denmark. According to him- *“it appears that after the course of a certain number of years, the appearance of the sun repeats itself with respect to the number and size of the spots”*.

Later, in 1843 astronomer Samuel Heinrich Schwabe [15] noticed a periodic variation in the average number of sunspots after 17 years of solar observations. He continued his observation for next 23 years. Meanwhile in February 1755, another astronomer Rudolf Wolf designated the first number cycle [16] (i.e. solar cycle no -1 or SC-1) and created a standard sunspot number index (so called Wolf number) which is continuing till today.

Regarding sunspots, astronomer Gustav Spörer noticed a few sunspots during the period 1645 – 1715 and recorded his observation. While the cycle's physical basis was demonstrated by George E. Hale and his team in the year 1908 indicating that

- 1) The sunspots were strongly magnetized ;
- 2) In the same heliographic hemisphere the bipolar active regions maintain to have the same leading polarity ;
- 3) While in the opposite hemisphere these bipolar active regions tend to have opposite leading polarity;
- 4) The leading polarities in both the hemispheres flip from one sunspot cycle to the next.

3. Decoding Fibonacci and the Real Pulse of Nature

3.1 The Golden Ratio

In the binary logic machine the only two parameters i.e. 0 and 1 are effective to understand the realistic nature of the universe — physics, chemistry, biology, medicine. Agriculture, even consciousness also. But for understanding the pulses or rhythms of nature we require Fibonacci rhythms in the form of fractal geometries that offer mirror pattern of the holographic universe. For example: in the case of the sun, the solar cycle and its associated sunspots.

Italian scientist Leonardo Pisano Bogollo (known as world famous “Fibonacci”) [17] first found a sequence of whole numbers: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, These numbers are called Fibonacci numbers and this infinite sequence is called Fibonacci Sequence. The main characteristic of this Fibonacci numbers or terms is that

- 1) Each term is the sum of the two preceding ones, starting from 0 and 1;
- 2) The ratio of successive Fibonacci number is called the golden ratio (ϕ) which is equal to $\phi = 1.6180339887498948 \dots\dots$;
- 3) If we consider the large numbers in the Fibonacci sequence then this ratio becomes closer to the golden ratio i.e. $\phi = 1.61803$.

This means the Fibonacci numbers are directly and intricately related to another very special mathematical formula that is found all throughout life and the physical universe. This is the “golden ratio” or phi (ϕ). The significance is that it is an irrational number (i) who's decimal place is never ending, (ii) non-repeating, and (iii) goes on forever i.e.

1.6180339887498948482045868348656381177203091798057.....to infinity, and (iv) for most effective scientists, academics alike have rounded it off to five decimal places (i.e. for all intensive purposes) i.e. the golden ratio = $\phi = 1.61803$.

3.2 Fibonacci: The Rhythm of Everything

Thorough investigations, studies suggest that a forest, a sunflower, a trace of the spiral of sea-shell, etc all encounter same thing astonishing fact- a recurring sequence that shapes life itself which is known as the Fibonacci sequence which not just a mathematics but it's a living rhythm encoded into the natural world.

In fact, the Fibonacci sequence appears to:

- Branching of blood vessels and neurons- human, animals [18]
- Plant phyllotaxis- leaf arrangements [19]
- Shell spirals and seed heads [20]
- Weather systems- cyclones, hurricanes [21]
- Galactic spirals- across the cosmos [22]

3.3 Fibonacci sequence Vs solar connection

Looking back into ancient mythological view, the sun was considered as a “living deity” or “cosmic eye “. On the other hand modern science / theories attempt to find a link between the solar cycles, sunspots and the Fibonacci sequence in the form of a pattern of divine cosmic order. In this context the remarkable investigation was performed by Richard [13]. Considering the length of solar activity variation for the period 1 – 12 years he measured the rigid rotation of the sun with the helioseismological frequency 433 ± 3 nHz in the radiative zone. Denoting one rotation of the sun by “ Ω ” the significant results in his study were:

- 1) The most frequent (modal) sunspot-cycle length = $144 \pm 2\Omega$ for the recurrence of sunspot cycles.
- 2) In the ascending leg the most frequent length is $55 \pm 1\Omega$, while in decending leg that length is $89 \pm 2\Omega$.
- 3) The harmonics of the period 144Ω i.e. 144, 89,55 may be kinematical threshold in the dynamical process which is responsible at sunspot maximum so that the poles change its polarity and the process is reset.
- 4) As the ratio of two consecutive Fibonacci number (F_n) converges to $(1+\sqrt{5})/2$ implying that this proportion plays a crucial role in solar behavior over time.

This means the Fibonacci sequence may be effective in solar actions i.e. solar cycle and sunspots.

4. Calculation

I consider the duration of rise time (i.e. ascending) during which sunspots are observed, the total duration of the cycle, and the total number of observed sunspots in each cycle for the past 24 solar cycles. Each cycle starts with minimum number of sunspots and reaches maximum (i.e. time of rise), so called “solar maximum”, and from that point descends gradually till the cycle is completed (i.e. total duration). I calculate the ratio i.e. total duration of solar cycle (SC) to the duration of rise-time and then compare this ratio with the available data [23 – 31] of the observed sunspots in each

cycle as tabulated in table 1. Out of 24 ratio values the three ratios are less than 2 i.e. for SC-1, SC-5, and SC-7; only for SC-24 it is ≈ 2 ; for 9 SC the ratio values are around 3, while value three for two cases i.e. SC-18 and SC-22. After rounding up all the estimated ratio values I found that out of 24 number ratio values 19 ratio values are following the Fibonacci number (F_4) = 3. Finally, it is seen that the maximum number of sunspots appears when the percentage (%) of deviation approaches to 0 (zero). In the case of SC-19 the ratio value of total duration to the duration of rise-time is 2.6923 i.e. the deviation percentage of -0.10285 gives the highest number of sunspots i.e. 285 among that of for all the 24 number solar cycles.

5. Significance of this Findings

Based on the above investigation it is suggested that the highest or maximum number (i.e. > 285) of sunspots may be appeared in that cycle when the deviation percentage (from the Fibonacci number $F_4 = 3$) of ratio value approaches to zero (0). i.e. the ratio value approached to exactly 3.

For observing the sunspots more than 285 we have to wait for observation of future solar cycles.

Table 1: Rise time, Total time, Deviation percentage and Maximum number of Sunspots for all the past 24 solar cycles.

S No	Duration of Rise-Time (yr)	Duration of Total Cycle (yr)	Ratio = Total Duration/ Rise time	Ratio rounded up	Fibonacci Number	Deviation % from Fibonacci Number $F_4 = 3$	Maximum no of Sunspots observed	Whether follow the Fibonacci Number or not in the Fibonacci sequence
1	6.3	11.3	1.79365	2	2	- 10.3175	144	Yes; $F_1, F_2 \rightarrow F_3$
2	3.3	9.0	2.72727	3	3	-9.9091	193	Y: $\rightarrow F_4$
3	2.9	9.3	3.20689	3	3	+6.89655	264	Y: $F_4 \rightarrow$
4	3.4	13.6	4.0	4	5	-20.0	235	Y: $F_4 \rightarrow F_5$
5	6.8	12.3	1.80882	2	2	-9.559	82	Y: $\rightarrow F_3$
6	5.8	12.8	2.20689	2	2	+10.3445	81	Y: $F_3 \rightarrow$
7	6.5	10.5	1.61538	2	2	-19.231	119	Y: $\rightarrow F_3$
8	3.3	9.7	2.93939	3	3	-2.0203	245	Y: F_4
9	4.6	12.4	2.69565	3	3	-10.145	220	Y: $\rightarrow F_4$
10	4.2	11.3	2.690475	3	3	-10.3175	186	Y: $\rightarrow F_4$
11	3.4	11.0	3.47058	4	5	-30.5884	234	Y: $F_4 \rightarrow F_5$
12	5.0	11.3	2.26	2	2	+13.00	124	Y: $F_3 \rightarrow$
13	3.8	11.8	3.10526	3	3	+3.550866	147	Y: $F_4 \rightarrow$
14	4.1	11.5	2.80487	3	3	-6.59433	107	Y: $\rightarrow F_4$
15	4.1	10.1	2.46341	3	3	-17.88633	176	Y: $\rightarrow F_4$
16	4.7	10.1	2.14893	2	2	-28.369	130	Y: $\rightarrow F_4$
17	3.6	10.4	2.8888	3	3	-3.70666	199	Y: $\rightarrow F_4$
18	3.3	10.2	3.09090	3	3	+3.03	219	Y: $F_4 \rightarrow$
19	3.9	10.5	2.6923	3	3	-0.10256	285	Y: $\rightarrow F_4$
20	4.1	11.4	2.78048	3	3	-7.31733	157	Y: $\rightarrow F_4$
21	3.8	10.5	2.76315	3	3	-7.895	233	Y: $\rightarrow F_4$
22	3.2	9.9	3.09375	3	3	+31.250	214	Y: F_4
23	5.3	12.3	2.32075	2	2	+16.0375	180	Y: $\rightarrow F_3$
24	5.3	11.0	2.0754	2	2	+3.77	116	Y: F_3

Note: $F_n \rightarrow F_{n+1}$ indicates previous Fibonacci numbers (F_n) are satisfied and then approaching to next Fibonacci number (F_{n+1})

6. Conclusion

In the eyes of Hindu mythology the sun was considered as a God / deity, the solar cycles as the visible manifestation of cosmic order as well as the eternal passage of time. Not only that, the mythology and the cosmology surrounding the sun at present are deeply intertwined through the physical cycles of the sun with the natural world. In Hindu mythology the sun traverses the whole sky on a brilliant chariot pulled by seven white horses. In realistic sense these seven horses symbolize the seven days of the week as well as seven colours of visible light. In fact, His (sun's) daily movement across the heaven or sky governs the rhythm of day and night that we are observing in our daily life as it a cosmic order. This means on a cosmic scale the sun drives the rotation of time itself implying that the cyclical nature of the universe is tied to the sun's position which has overarching role in the cosmic calendar like the culmination in the dissolution (i.e. destruction or Pralaya) before beginning a new cycle of creation.

In our modern scientific view the solar cycle is nothing but the solar magnetic activity cycle, sunspot cycle or Schwabe cycle is a periodic 11-year change in the sun's activity measured in terms of variations in the number of observed sunspots on the surface of the sun. Depending on the levels of solar radiation and ejection of solar materials the number and size of the sunspots, solar flares, and coronal loops all these exhibit a synchronized fluctuation over the period of a solar cycle from a period of minimum activity to a period of maximum activity and then returning back to a period of minimum activity. Numerical investigation of solar rotation period with the Fibonacci numbers showed that the Fibonacci number 144, 89 and 55 are applicable / effective on the sun's activity. Analyzing the deviation percentage and rounding it up I show solar activity follow the Fibonacci numbers 1, 2, 3, If we assume mythological seven white horses have the realistic meaning then solar activity may be capable to exhibit Fibonacci sequence i.e. estimated ratio of observed parameters in the solar cycle might be represented by the seven Fibonacci numbers in the Fibonacci sequence. In this study it is found $F_1, F_2 = 1, F_3 = 2, F_4 = 3, F_5 = 5$ in the

Fibonacci sequence that followed by the solar activity. $F_6 = 8$, and $F_7 = 13$ are not yet found. This means these two Fibonacci numbers remain as mystery till today and that need further investigation. The essential parameters can only be available from the observation of solar cycles i.e. SC-25, SC-26, SC-27, ...to be occurred in future.

This author, therefore, encourages the scientists, astronomers associated with the solar research community to take attention in this matter during their observations.

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