World Journal of Condensed Matter Physics, 2024, 14, 1-9
https://www.scirp.org/journal/wjcmp
ISSN Online: 2160-6927
ISSN Print: 2160-6919

Jovian Planet Influence on the Forcing of Sunspot Cycles

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How to cite this paper: Cadieu, F.J. (2024) Jovian Planet Influence on the Forcing of Sunspot Cycles. *World Journal of Condensed Matter Physics*, **14**, 1-9.
https://doi.org/10.4236/wjcmp.2024.141001

Received: November 3, 2023
Accepted: January 23, 2024
Published: January 26, 2024

Abstract

The history of our solar system has been greatly influenced by the fact that there is a large gas giant planet, Jupiter that has a nearly circular orbit. This has allowed relics of the early solar system formation to still be observable today. Since Jupiter orbits the Sun with a period of approximately 12 years, it has always been thought that this could be connected to the nearly 11-year periodic peak in the number of sunspots observed. In this paper, the Sun and planets are considered to be moving about a center of mass point as the different planets orbit the Sun. This is the action of gravity that holds the solar system together. The center of mass for the Jupiter-Sun system actually lies outside the Sun. The four gas giant planets dominate such effects and the four gas giant Jovian planets can be projected together to determine an effective distance from the Sun's center. Taken together these effects do seem to function as a sunspot forcing factor with a periodicity very close to 11 years. These predictions are made without consideration of any details of what is happening in the interior of the Sun. From these estimates, sunspot cycle 25 will be expected to peak in about September-October of 2025. Sunspot cycle 26 should peak in the year March of 2037.

Keywords

Sun Cycles, Solar System Formation, Jupiter

1. Introduction

Our Sun, our nearest star, has usually been observed to exhibit a maximum number of sunspots about every 10 - 12 years. [1] [2] There have been attempts to connect these sunspot variabilities to influences from the motion of the planets. [3] But the connections have not been usually supported by data and calculations or accepted as to how a relatively small mass such as the Earth or Venus could influence the magnetic behavior of a massive object such as the Sun. A recent paper rebuts any assertion that the motion of the planets Mercury, Venus, Earth and Jupiter could tidally synchronize the solar dynamo. [4] Other efforts have used details of sunspot cycles and appearances to study the detailed changes in the Sun. [5] [6] In contrast to this approach, we make predictions about the behavior of the Sun just from the action of gravity. The start of our Sun is generally ascribed to a result of the Nebular model. In this model, the mass of a region of space is caused to start to contract and then gravity supplies the energy source to increase the kinetic energy and generate heating. This is a lengthy process by human civilization timescales because the mass region in the case of our Sun spans a region of space with a radius of 4 to 5 light years to the next nearest star and even a single molecule traveling at 10^3 meters per sec would take ≈3 million years to travel 10 LYr. The general star formation process for low mass stars has been well described by others. [7] Low mass stars generally start out as part of a cluster of similar stars. Recent thought is that our Sun started as part of a cluster but was dispersed by some supernova event. [8] Our Sun for its final formation stage seemed to be alone and to have a friendly Jupiter which allowed long term stability in the solar system. Certain events wind up as characteristics of the early Sun. One of these relates to the start of specific layers in the convection zone. [9] Another relic is the peak in the magnetic field strength upon the formation of the Sun. [10] [11] Another is the counter rotation of Venus that resulted from the interaction of the Sun's peak magnetic field at this start with the nonmagnetic, but electrically conducting core of Venus. [12] The central star winds up with at least 99% of the system mass, but with only a small fraction of the system angular momentum. There are a great number of possible star states possible but here we are mainly concerned with the detailed start of our star. In this case, the central star wound up with about 99.8% of the star system mass and a planetary system of four terrestrial planets and four farther out gas giant planets. [13] [14] Jupiter carries most of the angular momentum of the solar system with the Jovian, gas giant planets contributing 3.1e43 kg m^2/s and four terrestrial planets only contributing 4.9e40 kg m^2/s. The Sun itself has an angular momentum of 1.92e41 kg m^2/s. The gas giant planets seem a necessary part of the solar system such that the Sun could form with a low angular momentum. The Sun wound up with a time varying magnetic field as tubules of ionized particles were drawn together to form the Sun. There are also other minor planets and other structures both orbital and spherical but the overall extent of the Solar System is very small compared to the size of the region of space from which the Sun formed.

Ever since sunspots have been observed their number has generally been seen to increase in roughly an 11-year cycle. Several probabilities need to act together for the existence of any specific sunspot. The overall polarity of the Sun's magnetic field switches polarity for each approximately 11-year cycle and then reverses again so that there is an overall approximately 22-year solar cycle. A number of other cycles have been observed that seem to depend on details of the

Sun interior. [5] [6] The reasons for these variations in the number of observed sunspots have generally been mysterious. In this paper, we wish to point out a correlation between the properties of our solar system and the observed number of sunspots as a function of time. Here the effects of gravity are the principal consideration.

2. Results

It is useful to consider that a star and planet move about a center of mass of the sun-planet system. One method of detecting exoplanets is to observe the wobble of a star due to the motion of a star-planet motion about a center of mass. [12] This effect shows up as systematic variations in the radial velocity. As expected, it is a very good approximation that the various terrestrial planets orbit about the center of mass of the Sun itself. But it should be noted that for the Jupiter-Sun system, the center of mass of the Jupiter-Sun system actually lies outside the physical radius of the Sun. For the other gas giant, "Jovian" planets, the distance from the center of mass of Jovian planet Sun system is an appreciable distance away from the center of the Sun itself. Properties of the Sun that depend upon the convection zone such as the Sun's magnetic field can then be expected to be perturbed by the cyclical motion of the center of mass as the planets orbit about the Sun. If X equals the distance from the center of the Sun to the center of mass and D equals the distance from the center of the Sun to the center of a planet then

$$M_S X = M_P \left(D - X \right) \quad \text{then} \quad X = \left(\frac{M_P}{M_S + M_P} \right) D \tag{1}$$

Dividing X by the radius of the Sun, R_S, then yields a useful variable $Z = X/R_S$. If $Z > 1$ then the center of mass of the Sun planet system actually lies outside the surface of the Sun. The Z values for the terrestrial planets are very small. For the Jovian planets: Z Jupiter = 1.07, Z Saturn = 0.586, Z Uranus = 0.180, and Z Neptune = 0.332. **Figure 1** shows the ratio of the distance from the center of the Sun compared to the Sun radius for the individual planets. The Z values for the terrestrial planets are very small compared to that of the Jovian planets. For example, the Z value for Venus is 3.8E-04 compared to a value of +1.07 for Jupiter.

The orbital period for the Jovian planets is P Jupiter = 11.86 years, P Saturn = 29.42 years, P Uranus = 83.75 years, and P Neptune = 163.7 sidereal years. [13] Using circular orbits angular speeds can then be determined by dividing 360 degrees by the orbital period. These are then 30.35 degrees per year for Jupiter, 12.24 degrees per year for Saturn, 4.299 degrees per year for Uranus, and 2.199 degrees per year for Neptune.

If for example, Saturn is located out beyond Jupiter then the center of mass will move farther out away from the Sun center. And conversely, if Saturn is on the other side of the Sun, then the center of mass will move back toward the center of the Sun. It is useful then to determine a projection of the center of mass Z values for different dates. This can be done by using a mathematical program

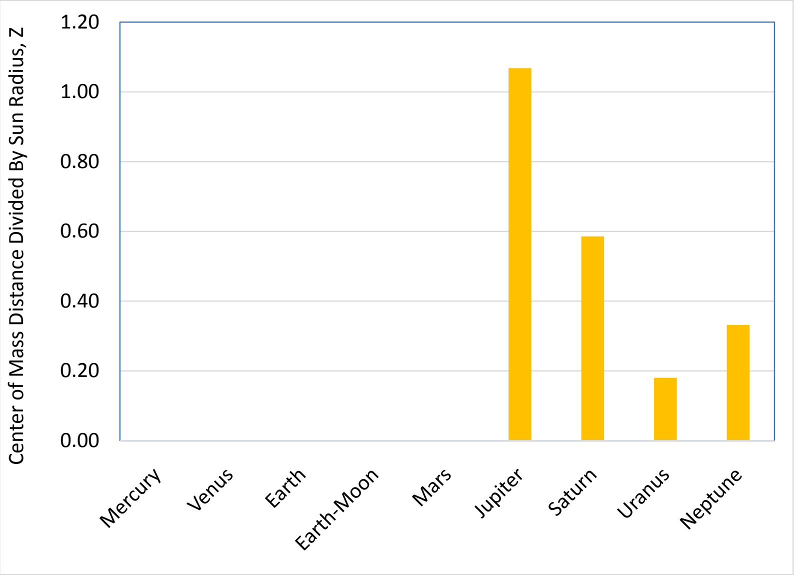

Figure 1. The distance from the Sun center to the center of mass compared to Sun's radius, the Z value, is shown for the planets in the solar system. Since the mass of the Sun is approximately 300,000 times the mass of the Earth, the Z values for the terrestrial planets are very small.

such as Mathematica, but it is probably easier to use an app such as "ThePlanetsToday.com". [15] This app allows the orbital position angles of the different planets to be determined for a series of different dates. The Z values can then be projected onto a particular axis direction for the different dates. The use of Mathematica allows details of the orbit and distances to be determined, but it is mainly the orbital angular positions that are of interest and the app gives the angular orbital positions and only that information.

In **Figure 2** the positions of the solar system planets are shown for a particular date such that the Earth and Jupiter are located at an angle of 270˚ as measured counterclockwise from the vertical line through the Sun. The figure results from "The Planets Today.com" app. Contributions from the planets Saturn, Uranus and Neptune can be similarly added. Note that if measurements are always made at the same time of the year the relative position of the Earth stays fixed at an angle of 270˚ in this example. The projected Z values are then given by

$$Z = -\left[1.07 * \mathrm{Cos}\left(\theta_J\right) + 0.586 * \mathrm{Cos}\left(\theta_S\right) + 0.180 * \mathrm{Cos}\left(\theta_U\right) + 0.332 * \mathrm{Cos}\left(\theta_N\right)\right] \quad (2)$$

where the coefficients as determined by Equation (1) and subscripts refer to the planets Jupiter, Saturn, Uranus, and Neptune. This equation determines the projected Z values as the different planets rotate. The minus sign originates from the choice that angles increase in the counterclockwise direction.

Figure 3 gives the sum of the projected Z values for the time period from 1930 to 2040. Z values have been determined for every tenth of a year. The projected Z values cover the range from approximately −2 to +2 in a regular pattern. For this time period the number of sunspots varies in what is generally considered as a normal manner with the number of sunspots peaking approximately every 11 years. It was always possible to pick either an extremal positive or negative, or local extremal value, to agree with observed sunspot cycle dates. But not all extremal values correspond to the number of sunspot maximums.

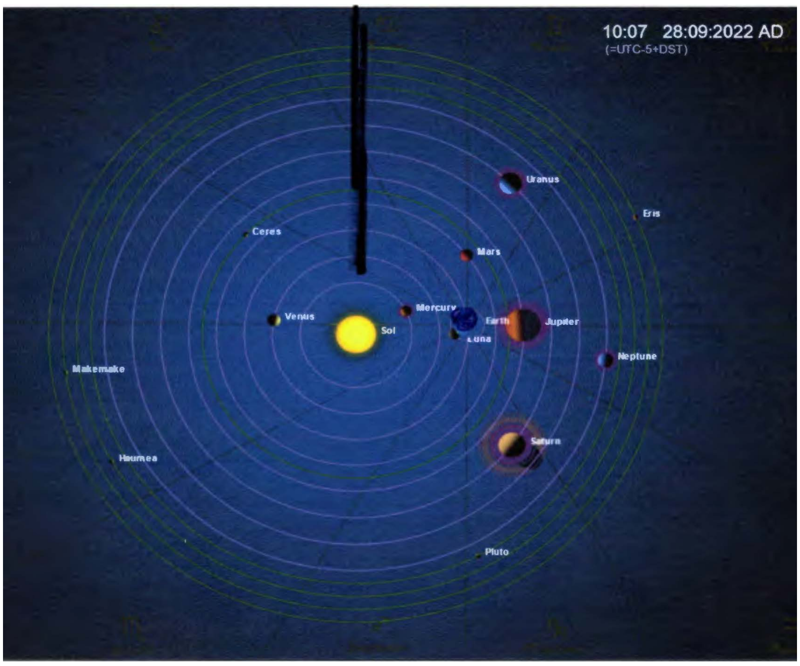

Figure 2. The relative angles to the planets in the solar system are shown as determined by the app The-Planets-Today.com. The angles have been determined by the angle measured counterclockwise from the vertical line. Projected Z values have been determined for every tenth of a year.

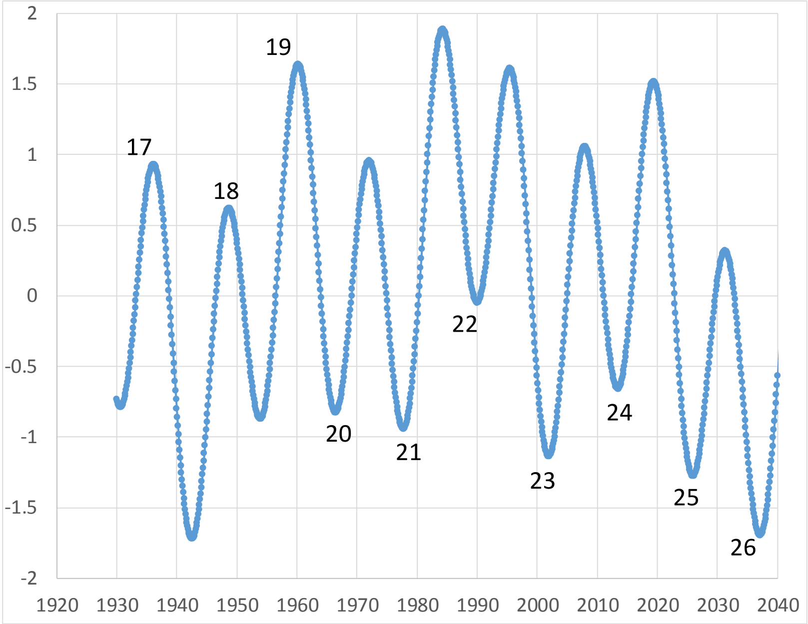

Figure 3. The projected Z values are shown for the time period from 1930 to 2040. The corresponding Sunspot Cycle Number are indicated by the numbers running from Cycle Number 17 to projected Cycle Numbers 25 and 26.

If Z is considered as a sunspot driving factor then extremal values of Z with both positive and negative values have high driving factor effects. **Figure 4** shows counts of the number of sunspots observed for sunspot cycles 16 to 25. [16] The number of sunspots peaks are generally at least 1 to 2 years wide. Sunspot cycles 19, 21, 22, and 23 exhibited a greater number of observed sunspots, while cycles 20 and 24 exhibited fewer than some average values.

The number of observed sunspots then seems to be the product of some stochastic process depending on the details of the Sun and an overall forcing function. **Table 1** collects information from **Figure 3** and **Figure 4** for comparison. Data for Cycles 1 to 24 for past cycles are indicated as well as for future cycles 25 and 26. Column 2 indicates the smoothed monthly number of sunspots observed. Column 3 indicates the date for the cycle peak value. The observed peak values are broad and noisy, particularly for lower count values. Column 4 indicates the date determined from the Z values. Positive extremal Z values correspond to sunspot cycles 17, 18, and 19. Negative extremal values at 1967, 1978, 1990, 2001.9, 2014.5, 2025.9, and 2037.2 then correspond to cycles 20 to 26. Column 5 indicates the observed cycle date minus the predicted Z expected date. Most of these difference values are less than 1 year.

Figure 5 shows the determined Z values for the time period from 1740 to 1950. The time period from 1790 to 1815 corresponds to the time period known as the Dalton Sunspot Minimum. Sunspot Cycles numbers 5 and 6 occur in the Dalton Minimum and are indicated by the oval region in **Figure 5**. The Dalton sunspot minimum corresponded to a reduced level of sunspots as indicated in **Table 1**.

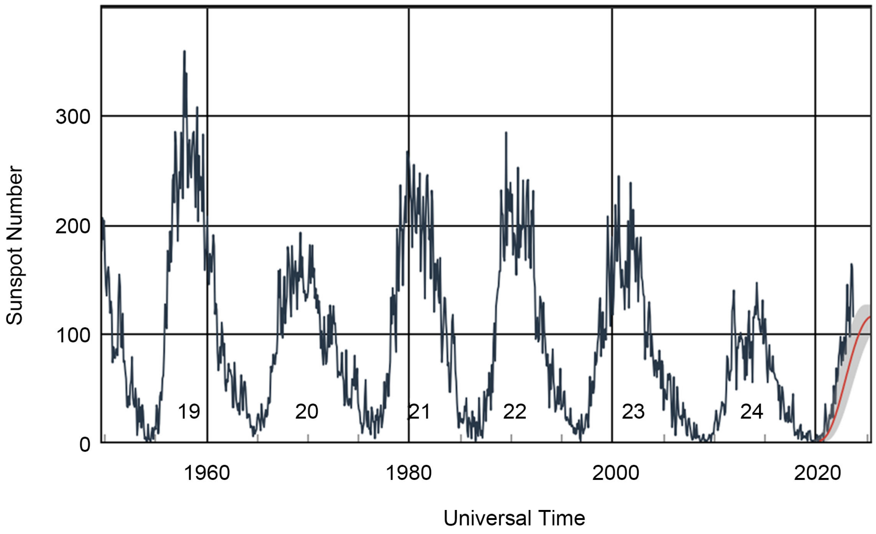

Figure 4. The observed number of sunspots is shown as determined by the Space Weather Prediction Center, NOAA.gov for the time period from 1950 to 2025. The probability of any particular sunspot is a fairly noisy function of time. The probability does not actually go to zero for the minimum time periods. The values for Cycle 25 are projected values. [17]

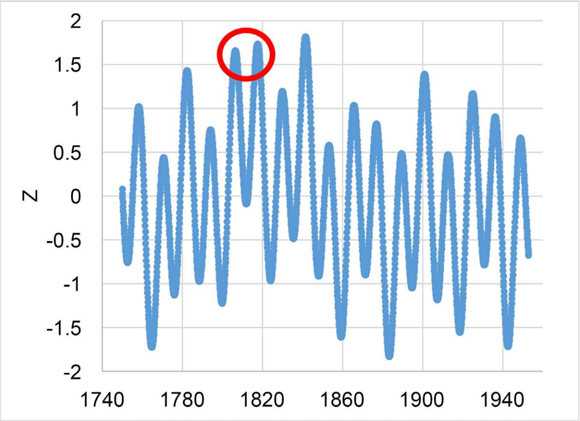

Figure 5. The Z values are shown for the time from 1740 to 1950. The Dalton Sunspot Minimum time period was from 1790 to 1815. The **Table 1** values have been determined from such plots. Projected Z values have been calculated for every tenth of a year.

Table 1. Columns 1, 2, and 3 show the Sunspot Cycle Number, the Smoothed Monthly Number of Sunspots, and Date of Peak Number from SWPC. Column 4 shows the date of the Peak Number Predicted by the Z value. Column 5 shows the difference in dates, Date SWPC − Z Date.

Sunspot Cycle #	Smoothed Monthly Number of Sunspots	Date of Peak Number From SWPC	Date Predicted by Z Value	Date SWPC − Z Date
1	141.3	1761.7	1761	0.7
2	190.1	1768.8	1768	0.8
3	252.9	1778.6	1779	−0.4
4	234.1	1788.3	1788.5	−0.2
5	75.1	1803.9	1803	0.9
6	77.1	1816.8	1816.9	−0.1
7	116.9	1829.7	1830.2	−0.5
8	244.9	1837.3	1836.3	1
9	213.9	1848.5	1848	0.5
10	185	1860	1859.6	0.4
11	234	1870.7	1871.3	−0.6
12	123.7	1883.8	1883.3	0.5
13	143.6	1893.8	1894.7	−0.9
14	104.6	1907.5	1907.5	0
15	175.7	1917.7	1918.6	−0.9
16	128.9	1928.3	1928	0.3
17	184.8	1937.7	1937	0.7
18	199.8	1948.7	1948.3	0.4
19	281.8	1958	1960	−2
20	156.6	1968.9	1967	1.9
21	199.6	1981	1978	3
22	203.8	1991.3	1990	1.3
23	180.3	2001.9	2001.9	0
24	114.1	2013.4	2014.5	−1.1
25	“115.0”	“2025.7”	2025.9	
26			2037.2	

3. Conclusions

As noted from **Figure 1**, the Z values for the terrestrial planets are very small compared to those for the Jovian planets. This means that the 4 terrestrial planets to a very good approximation rotate about the center of the Sun, but that the Sun and the Jovian planets rotate about the system center of mass. The implications of this for the Drake equation and how special our Solar System is, will be addressed in a separate paper.

An update prediction has been made by the Space Weather Prediction Center that sunspot cycle 25 will peak in July 2025. [17] This is nearly 2 years in the future at the time of this writing. The Z value prediction with no adjustable parameters is that cycle 25 will peak in September-October of 2025. Nine cycles of Z span 100.0 years for an average of 11.1 years per cycle. In addition, it is predicted Cycle 26 will peak in about March of 2037. If these future predictions prove accurate, then the modeling will be supported. Usually, sunspot studies have been made without any consideration of gravity. But the gas giant planets acting together through gravity do seem to function as a forcing factor for the generation of sunspots. It should be noted that no details about the interior of the Sun have been introduced and yet the Z values correspond very well to the peaks in the observed dates of the Sunspot Cycles.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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