Impact Generated Shockwaves are Proposed for the Origin of Sunspots to Explain the Detected Planetary Correlations with Solar Activity

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Abstract Correlations between solar activity and the heliocentric longitudes of Jupiter, Neptune and Uranus at the time of the syzygies of Jupiter and Saturn are detected. In order to explain these correlations it is suggested that the resonance of the outer planets destabilizes the orbit of Kuiper Belt Objects and generates a cyclical impact frequency on the Sun. The vaporization of the object initiates a shock way disrupting the upwelling of the plasma resulting in a sunspot formation. The proposed model is able to explain the length of the cycle, the latitude distribution of the sunspots and the extremely long term stability of the cycles. Calculating the positions of the Jovian planets at syzygies of Jupiter and Saturn allows the long term prediction of the solar activity.

Keywords sunspots; solar activity; impact; Jovian planets; solar cycle prediction

1. Introduction

The close coincidence of the sideral period of the largest planet, Jupiter (11.87), with the about eleven-year cycle of the solar activity has been known for long time. Based on this coincidence many author investigated the relationship between planets and solar activity and various correlations have been identified (Wolf 1859; Chase, 1873; Brown 1900; Schuster 1911; Jose 1965; Wood & Wood 1965; Bigg, 1967; Wood 1972; Blizard 1981; Fairbridge & Hameed, 1983; Fairbridge & Shirley 1987; Charvátová, 1988; Javaraiah & Gokhale,1995; Zaqarashvili, 1997; Landscheidt, 1999; Shirley et al. 1990; Juckett, 2000; Javaraiah, 2003; Charvátová & Střeštík, 2007; Wilson et al., 2008; Charvátová, 2009). The correlations provide considerable circumstantial evidence and suggest that planets affect solar activity.

The only long range effect of the planets which might have influence on solar activity is gravity. It has been shown that the tides induced on the surface of the Sun are too small to have significant influence on solar activity (Smythe & Eddy, 1977). The Sun orbits about the center of the mass of the Solar System in a serious of complex spirals (Jose, 1965). The planetary induced torques acting on the sun might have effect on solar activity (Jose, 1965; Zaqarashvili, 1997; Shirley, 2006; Wilson et al., 2008). The affect of this spin-orbit coupling mechanism is the strongest when Jupiter and Saturn are in conjunction and the weakest when they are in opposition (Wilson et al., 2008). Calculating the heliocentric longitudes of the Jovian planets (Smith, 1981) at the time of the syzygies of Jupiter and Saturn (SJS) correlations between solar activity and planetary positions are investigated.

2. **Correlations Between Solar Activity and the Positions of the Jovian Planets**

In the period of 1700-2008 thirty SJS occurred and 28 solar cycles -4 through 23 was observed. Investigating the time between solar maximums it can see that between cycles 4 and 5 and between 11 and 12 two SJS occurred or one SJS was skipped. Wilson et al. (2008) have been suggested that SJS are skipped when phase catastrophes occur. They also identified a cycle with phase catastrophe some time before cycle -4. The Maximum sunspot number following a skipped SJS is significantly reduced in the following three cycles. Wilson et al. (2008) suggested that these cycles were in phase-drift mode. Based on this definition solar cycles -4; -3; 5-7 and 12-14 are identified with phase-drift mode. The investigated data set contains 20 cycles with phase-locked and 8 cycles with phase-drift mode. I will call the cycles with phase-locked to regular and the cycles with phase-drift to irregular cycles. The effect of SJS on these two groups of cycles is investigated separately.

The Greenwich data set of the yearly average latitude of the sunspots shows systematic behavior in relations to SJS (Fig. 1). The lowest latitudes do coincide with the time of SJS in seven cycles (15-20). The first three solar cycles (12-14) of the data do not follow this pattern. Cycles 12-14 are irregular while cycles 15-20 are regular. It is suggested that one of the characteristics of irregular cycles is that the lowest latitudes of the sunspots do not coincide with SJS. Cycles are regular when the lowest latitudes coincide with SJS. The correlation between sunspot latitudes and SJS can be used to identify the characteristics (regular of irregular) of the cycle.

The heliocentric longitudes of the outer planets are calculated (Smith, 1981). The positions of Uranus and Neptune are represented by the angle between Jupiter and the planet at the time of SJS. Investigating the relationship between these orbiting components and the maximum yearly average sunspot number the following correlations have been detected:

$$\mathrm{MSSN}_{(R)} = 97.88 + 0.1255 \times \mathrm{JHL} \qquad R = 0.42 \tag{1}$$

where MSSN is the Maximum Sunspot Number (Yearly Average), JHL is the Heliocentric Longitude of Jupiter at the time of SJS and R is the correlation coefficient. Subscript R refers to regular cycles.

$$\mathrm{MSSN}_{(R)} = 143.05 - 0.2196 \times \mathrm{JU} \qquad R = 0.41 \tag{2}$$

where, JU is the angle between Jupiter and Uranus at the time of SJS.

$$\mathrm{MSSN}_{(R)} = 106.94 + 0.1835 \times \mathrm{JN} \qquad R = 0.33 \tag{3}$$

where JN is the angle between Jupiter and Neptune at the time of SJS. Combining these three effects gives the correlation:

$$\mathrm{MSSN}_{(R)} = 97.62 + 0.1545 \times \mathrm{JHL} - 0.2783 \times \mathrm{JU} + 0.2144 \times \mathrm{JN}\,. \tag{4}$$

The correlation coefficient is 0.747 and the standard error is 21.05. For irregular cycles:

$$\mathrm{MSSN}_{(I)} = 52.78 + 0.0462 \times \mathrm{JHL} + 0.0773 \times \mathrm{JU} - 0.1010 \times \mathrm{JN}\,. \tag{5}$$

The correlation coefficient is 0.585 and standard error is 13.48.

Equations (4) and (5) have upper (192) and lover (36) limit on the Maximum Yearly Average Sunspot Number. Thus the determined correlations do not applicable to the period of the Maunder minimum indicating that additional term/s might be required for longer and more precise description of the solar activity.

The length of the cycle (minima) (Rogers et al., 2006) correlates to the same variables as:

$$L_{(R)} = 9.946 + 9.67 \times 10^{-4} \times \mathrm{JHL} + 9.20 \times 10^{-3} \times \mathrm{JU} - 2.26 \times 10^{-3} \times \mathrm{JN}\,, \tag{6}$$

where L is the length of the cycle in years. The correlation coefficient is 0.48.

Using equations (4) and (5) the maximum sunspot numbers are calculated from the orbiting parameters of the Jovian planets. The calculated values of cycles -4 through 26 are plotted against observations (Fig. 2). The agreement is reasonably good.

3. Interpretation of the Correlations

The presented correlations between solar activity and the position of the Jovian planets eliminate the likelihood that these correlations are random coincidences.

The correlations have some interesting features which can not be explained by the spin-orbit coupling mechanism. The gravitational effect of Neptune on the Maximum Sunspot Number is reverse in comparison to the gravitational effects of Jupiter and Uranus. The gravitational effects of the planets should be summed according to spin-orbit coupling model. The solar activity is affected by the heliospheric longitude of Jupiter. The spin-orbit coupling mechanism can not explain why the orientation of the SJS has affect on solar activity. The contributions of the tree different sources, Heliocentric Longitude of Jupiter, angle between Jupiter and Uranus and angle between Jupiter and Neptune at the time of SJS are 24%, 43% and 33% respectively. If the sunspot cycles are generated by the planetary induced torques acting on the sun than the contribution of Uranus and especially Neptune should be significantly smaller. Based on these inconsistencies it is suggested that the spin-orbit coupling is not the right mechanism to explain the planetary effects on solar activity.

Impact generated sunspot formation is proposed to explain the detected planetary effects in the solar activity. The gravitational effect of the Jovian planets destabilizes the orbits of solar system bodies resulting in an impact flux on the Sun. The impact flux is generated primarily by SJS which has the periodicity of 9.9 y. The evaporation of the projectiles hitting the sun produces a shock way which disturbs the upwelling of the plasma resulting in a sunspot formation (Garai, 2001).

The relative position of Uranus and Neptune to Jupiter slightly modifies the primarily cycle generated by SJS. The conjunction of Jupiter and Neptune at the time of SJS results in lower activity and longer cycle. On the other hand, the conjunction of Uranus and Jupiter at the time of SJS increases the intensity of the cycle and maintains the fundamental 9.9 y periodicity of the cycle. The solar activity following the triple conjunctions of J-S-U in 1762, and again in 1940, was very high in the following two cycles.

If the heliospheric longitude of Neptune is within 10^0 of Jupiter's heliospheric longitude while the activity is low, as occurred in 1703, 1792 and 1881, then the resulting depression and delay in the solar activity can cause the following two cycles to fully overlap and therefore not be noticed as independent cycle. This phenomenon did not occur in 1971 because the solar activity was too high at that time. These overlapping cycles modify the fundamental 9.9 y length of the solar cycle to the observed 11.03 y.

The objects hitting the Sun most likely originate from the Kuiper Belt. The inclination of the Kuiper Belt Objects is between 0-35^o (Luu and Jewitt, 2002; Jewitt et al., 2008) which is consistent with the observed latitude distribution of the sunspots.

The flux of the projectiles moving towards the Sun is further affected by the gravitational attraction of the inner planets, which explains why the orbiting periods of the inner planets are also detectable in the solar activity.

The nonrandom nature of the sunspot cycle and the latitude distribution is consistent with a planetary driven mechanism. The convection of the hot plasma which rises up from the interior sun and spreads out across the surface and then cools and sinks inward is random. Random process can not result in a non-random process. Thus the sunspot formation should not originate from and relate to random plasma convection.

The long term stability of the solar cycles also supports an astronomical driven process for the solar cycles. The 11 and 22 years cycles in the solar activity had been detected for hundreds of millions of years (Williams, 1981). Beside astronomical driven cycle, there is no known other process able to sustain this long-term stability. The only astronomical cycles consistent with length of the solar cycle are planetary orbiting periods.

The influence of the solar cycle was so much stronger 680 Myr ago than today (Williams, 1981). The weakening of the cycle can be explained by the depletion of the KBO. The well established relationship between mean star activity, age and rotational period (Ducan et al., 1991; Henry et al., 1996) is also consistent with a depletion and impact accretion process.

An impact model is also consistent with the cooler temperature of the sunspots and explains why most of the missing radiated energy at the site of the sunspots has never been detected (Rast et al., 1999).

The observed temperature differences in the sunspot umbra can not be explained by a continuum model (Van Ballegooijen, 1984). The two components cooling of the sunspots is consistent with an impact generated sunspot formation.

The observed butterfly distribution of the sunspots can be shown consistent with the proposed impact model. The impact free zone around the solar equator at the beginning of the cycle is the result of the shielding effect of Jupiter and Saturn.

4. Conclusions

Five new correlations between the orbiting position of the Jovian planets and solar activity is reported. These additional correlations between planetary positions and sunspot maximum are convincingly demonstrates that the planetary effects in solar activity are real and not an artifact. The detected correlations can not be explained by spin-orbit coupling mechanism; however, an impact generated sunspot formation is consistent with the detected correlations. The fluctuation of the gravitational field generated by the outer planets destabilizes the orbit of Kuiper Belt Objects and results in a cyclical impact frequency on the Sun. The vaporization of the object induces a shock way disrupting the upwelling of the plasma resulting in a sunspot formation. This model is able to explain the length of the cycle, the latitude distribution of the sunspots, and the long term stability of the cycles. The impact mechanism is also consistent with the non-random nature of the sunspot distribution, with the missing radiated energy, with the two components cooling of the sunspots and with the relationship between mean star activity, age and rotational period. The proposed model is testable using currently available equipments of observational astronomy.

The detected correlations allow calculating the maximum sunspot number and the length of the cycle from planetary positions. The calculated values reproduce the observed sunspot's activity reasonably well for the investigated 300 years. The presented correlation is the first one which is able to give reasonable prediction for long term solar activity.

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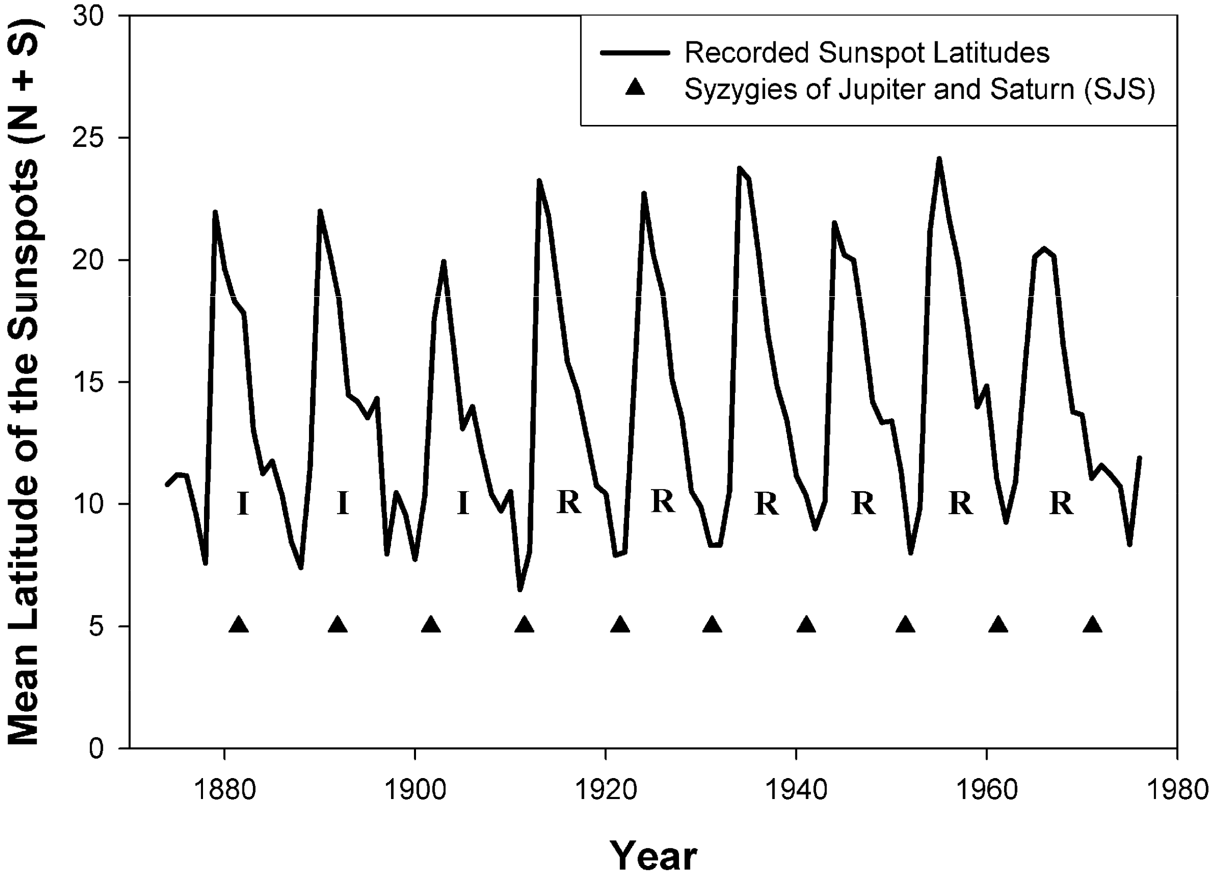

Figure 1 Correlation between the annually averaged latitude of the sunspots (Greenwich data set from 1874 to 1976) and the syzygies of Jupiter and Saturn. The letters R and I represents Regular and irregular cycles respectively.

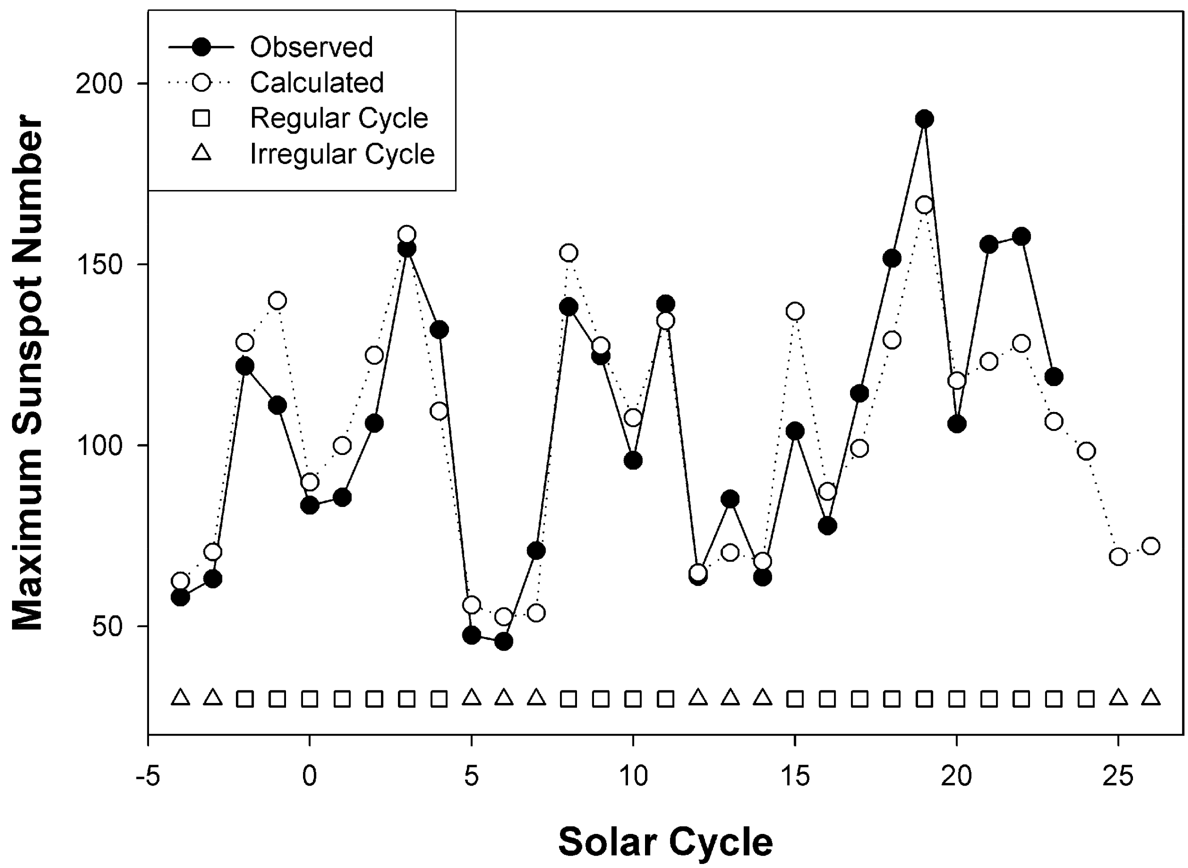

Figure 2 Using Equations 4 and 5 the maximum mean annual sunspot number for cycles -4 through 26 are calculated from the heliocentric longitudes of Jupiter, Neptune and Uranus which correspond to the syzygies of Jupiter and Saturn. The observed values are also plotted for comparison.