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Cycles of solar activity and the configurations of the planets

V P Okhlopkov
D. V. Skobeltsyn Institute of Nuclear Physics of M. V. Lomonosov Moscow State University (SINP MSU), Leninskie gory, Moscow, 119234, Russian Federation

E-mail: okhlopkov@taspd.sinp.msu.ru

Abstract. Using as a parameter the average difference between the heliocentric longitudes of the planets Venus, Earth and Jupiter, the strong link of 22-year and 11-year cycles of solar activity with the lowest values of the parameter have been found. The envelope curve of the minimum values of this parameter describes well both the conjunctions of the three planets, when they are almost in a straight line from the Sun, which causes the maximum of solar activity; and the conjunctions in larger longitudinal sector (25–30°), which occur much more frequently and are accompanied by different combinations of planets on the opposite sides from the Sun, that also causes the maximum of solar activity. The location of these planets on the opposite sides from the Sun in various combinations is well compatible with this parameter.

1. Introduction
Back in the mid-19th century R. Wolf suggested the hypothesis that solar activity was caused by the tidal influence of the planets on the Sun [1]. Many researchers then continued developing tidal hypothesis of solar activity [2–5]. In particular, Brown [2] proposed a hypothesis of the origin of solar activity cycles, according to which the change in activity was due to vortex motion in the solar atmosphere caused by planetary tidal waves. An important step in studies of solar activity was the work of Jose [6], in which the dynamic parameters of the Sun’s motion relative to the center of mass of Solar system (CMSS) had been calculated. Many researchers carried out various comparisons of parameters of the Sun’s motion relative to CMSS and solar activity to identify relationships, in particular [7–11]. In [12–13] the effect of barycentric motion of the Sun on solar activity was examined and it was shown, that the spectrum of barycentric motion had no peak near 11-year period, which determined the solar cycle. In [14] the dynamic parameters of the Sun’s motion relative to CMSS were investigated and the frequency spectra of these parameters and the Wolf numbers were calculated. The coincidence of periodicities in the Wolf numbers and the dynamic parameters of the Sun’s motion was shown. In [15] it was concluded that the influence of the planets on solar activity existed, although not by gravitational, but the electrodynamic forces.

2. A planetary configuration
In this paper, which is a continuation of [16], we have calculated the average difference between the heliocentric longitudes (ADL) for different combinations of planets. Below the details will be presented on the analysis of relationships of solar activity with the planetary configurations of Venus, Earth and Jupiter, because we could find a good connection with solar activity only for this combination of planets. For the three planets are three differences of longitude, which are averaged with equal weights. ADL were calculated for two time intervals: one interval from 1000 to 2050, and the other – from 1700 to 2050, using 5-day and 2-day steps accordingly for calculating the planet
coordinates. Positions of the planets on a single line from the Sun and on one side from it, i.e. at the same longitude, and in some sector of longitudes as well, will be called “a conjunction of the planets”.

In figure 1a the data on the ADL for the period from 1700 to 2050 are presented, bounded by the maximum values of 40°. From this figure one could clearly see that the minimum values of ADL have a clear periodicity (meaning the envelope curve of the minimum values of ADL). As the spectral analysis of this series shows, the main period of the envelope in it is equal to 22.14 years.

In figure 1d the selected points of the envelope (from figure 1a) are shown with the minimal ADL and limitations on the maximum angle of sector of planetary conjunction equal to 30° (we denote this number as ADL30). Also in figure 1b the time intervals between the conjunctions of the planets, shown in figure 3d, are given. From these figures it can be clearly seen, that if the conjunctions of the planets have minimum error for longitude, when ADL is less than 10°, then the time interval between the conjunctions is about 3.2 years. However, if we will take the minimum error for longitude equal to 20° but within the envelope, the time intervals between the conjunctions will amount to 1.3–2 years.

In the present study we have calculated the points of time when two of the three planets were in conjunction, and the third planet was on the other side from the Sun, but on one line with them and the Sun. It was found that at the extremums of the envelope of ADL, when the value was minimal (less than 5°) in the neighboring time intervals the conjunctions of Venus and Earth were observed with location of Jupiter on the other side from the Sun (figure 1c, this configuration is denoted K1). Whereas the extremums of the envelope of ADL are in the range of 25–30°, there exist two configurations of the planets. One configuration – when there is a conjunction of Venus and Jupiter, and the Earth is located on the other side from the Sun (figure 1c, this configuration is denoted K2). Another – conjunction of Earth and Jupiter with the location of Venus on the other side from the Sun (figure 1c, this configuration is denoted K3). All these three configurations clearly coincide with the extremums of the envelope curve of ADL. In essence, the envelope curve of ADL describes well both the conjunction of the planets with their location on one side from the Sun, and the combination of the planets with their location on the opposite sides from the Sun. Extremums of the envelope of ADL well matched with the maximums of 11-year variation of solar activity. 11-year cycles of solar activity is important for the modulation of GCR and SCR generation.

3. Comparisons with solar activity

In figure 1e,f the alternating series of Wolf numbers (denoted as Rz_*) and the usual Wolf numbers (denoted as Rz) are presented. In forming an alternating series of solar activity cycles with odd numbers on the Zurich numbering were taken with a plus sign, and even with the minus sign. Alternating series can be taken with the signs and vice versa, it does not matter. Since the main periodicity of ADL30 data is 22-year, a correlation analysis of Rz_* with a shift was performed. The correlation coefficient is -0.807 for Rz_* with a lag by an average of 10.4 years and +0.801 with zero shift and when Rz_* is ahead by 0.8 years. Of course solar activity can not outpace the factor which defines it; thus it must be concluded that the 22-year cycle of solar activity follows with a lag of about 10.4 years after the extremums of the envelope of minimum values of ADL of the planets Venus, Earth and Jupiter.

An important thing is the ratio between durations of 11-year cycles of Wolf numbers and of the parameter ADL (envelope ADL30). Comparison of durations of 11-year cycles of Wolf numbers and of the parameter ADL based on coincidence between them with the shift was carried out for the cycles followed after 1815, where the data on Wolf numbers were considered to be more representative. For these cycles, the average shift between the maximum of Rz and ADL was 10.2 years, mean duration of cycles was 10.96 and 11 years respectively, the average difference between the durations of 11-year cycles of Rz and ADL was 0.7±0.2 years. If we compare 11-year cycles of Rz and ADL without the shift, the average difference between the durations of 11-year cycles was 1.0±0.3 years. We should mention a better coincidence between lengths of 11-year cycles of ADL and Rz with the lag of Rz. For the period from 1815 to 2011 the main period of the envelope of ADL is equal to 22.0 years.
Figure 1. For the time from 1700 to 2050: a) mean difference between heliocentric longitudes of Venus, Earth and Jupiter, limited with the value of 40°; d) the envelope of minimum values of ADL, taken from (a) with the restriction of 30°, and b) time intervals between them; c) points of time for various configurations of planets for their location on the opposite sides from the Sun (the number of configurations K1 to K3, described in the text); e,f) alternating and usual series of Wolf numbers.

4. Discussion and Conclusion

The parameter ADL in the region of its least values has a very clear periodic envelope, the main period of which is equal to 22.14 years for the time interval from 1000 to 2050 year. Spectral analysis of the Shove series of solar activity, taken from 1000 year and completed with the series of Wolf numbers, gives a periodicity of 11.07 years, which is in full accordance with the periodicity of ADL, which extremums describe the 11-year cycles of solar activity.

From figure 1a follows that the minimum values of ADL (in this figure there are 16 of them) have different structure of the conjunctions of the planets, and this can probably explain the various forms of 11-year cycles of solar activity.

Analysis of the envelope of the ADL of the planets Venus, Earth and Jupiter from 1000 year shows that the duration of the 11-year cycles, allocated by the extremums of the envelope of ADL, vary in the range 7.8–14.3 years, and the frequency spectrum of ADL for this period gives the periodicity of 22.14 years (figure 2).

11-year and 22-year cycles of solar activity are determined by the envelope curve of the minimum values of the mean difference between the heliocentric longitudes of the planets Venus, Earth and Jupiter in two areas. One maximum of solar activity occurs when the difference in longitude of the planets is minimal, up to 5° ADL, the time intervals between these conjunctions are 3.2 years, and in
Figure 2. For the time period 1000 to 2050: a) points of time for various configurations of the planets Venus, Earth and Jupiter for their location both on the same and on the opposite sides from the Sun (the number of configurations K1–K3, described in the text); b) the envelope of minimum values of ADL of Venus, Earth and Jupiter, limited by the value of 30°, c,d) alternating and usual series of Wolf numbers.

the neighbouring time intervals we have the configuration K1. Another maximum of solar activity occurs when ADL are in the range of about 25–30°, when intervals between the conjunctions are much less, and in the neighbouring time intervals we have configurations K2, K3.

In these cases these planets either consecutively pass through several configurations, when being located almost in one line with the Sun or near it, or pass through several configurations with the ADL in the range of 25–30°, which is accompanied with the configuration of planets on the opposite sides from the Sun. The delay of the solar activity from the corresponding configuration of the planets of about 10 years may be demanded in the models of solar activity, in which the source of solar activity is at greater depths in the Sun (radiation zone of the sun) and at the bottom of the convection zone.

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