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The Jovian period in the Sun?

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Abstract

The 41-year measurements of the Doppler effect of the photosphere performed at the Crimean Astrophysical Observatory, discovered two periods of global oscillations of the Sun: 9600.606(12) s and 9597.929(15) s. Their beat period, 398.4(2.9) d, well agrees with a *synodic* orbital period of Jupiter, $P_J = 398.9$ d, raising a new problem for solar physics, cosmogony and cosmology. A hypothesis is advanced that the P_J beating of the Sun is induced by gravitation of Jupiter, revolving in a *privileged* reference system "the Sun – the Earth".

Keywords: The Sun; Photosphere; Oscillations; Jupiter; Reference system; Cosmology

1. Introduction

Behaviour of the Sun-as-a-star, with particular attention to its interior, is being studied at the Crimean Astrophysical Observatory (CrAO) since 1974. Here we report results of a long-term experiment: the regular, from day to day, quasi-continuous measurements of the line-of-sight velocity of the photosphere, carried out at the Severny's Solar Tower Telescope over last 41 years, from 1974 through 2014 (with gaps caused by nights, seasons, weather conditions and other circumstances).

The measurements were made in the Fraunhofer absorption line Fe I λ 512.37 nm (with zero Lande factor) using the Babcock-type solar magnetograph modified for Doppler observations. Instead of Zeeman effect, the instrument registers the difference of line-of-sight velocities between the circular central and the annular limb portions of the solar disk. The main results of this program were:

(1) the discovery of the 9600-s oscillations of the Sun (the precise period is $P_0 = 9600.606(12)$ s; the finding was made independently by Brookes et al. (1976); and Severny et al. (1976), being confirmed later by Grec et al. (1980); and Scherrer and Wilcox (1983)),
(2) the splitting or even disappearance of this global oscillation after approximately 1982 (Henning and Scherrer, 1988; Kotov et al., 1997),
(3) an emergence of the new oscillation, with the nearby period $P_1 \approx 9597.94$ s, in the 37-year set of the CrAO observations (Kotov and Haneychuk, 2011), and
(4) the remarkable fact that the difference of the two periods, through a beating formula, corresponds, within the error limits, to the *Jovian synodic orbital* period 399 d.

The Crimean measurements of solar pulsations were continued in 2011–2014, and now the total 41-year set of 5-min averages of the differential, "center minus limb", velocity contains $N = 170305$ values with standard deviation 6.4 m s^{-1} in the CrAO differential scale. These observations were performed during 2379 days, or 14,192 h in all (for the previous results and observational details see Kotov and Haneychuk (2011) and Kotov and Haneychuk (2015), and references therein). Positive velocity corresponds to "expansion" of the Sun, zero phase – to 0 UT, 1 January 1974.

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The first reviewer pointed out that the Doppler observations performed by the SOHO–MDI instrument (Scherrer et al., 1995) produced the alleged negative result. We note however that the MDI measurements which have been carried out, with some gaps, during a whole year (i.e. over a total Earth orbit), can hardly be compared with the CrAO measurements performed mainly from May through September. *This point acquires a special and very important meaning when one discusses a "mysterious" appearance of the synodic planetary period in the data*, see Section 3. (There are also other serious discrepancies in methods of measurements and data reduction procedures, which will be discussed elsewhere separately.)

Does the complete set of the CrAO observations confirm the presence of the new, shifted period P_1? Why the shift corresponds to the beating period ≈ 399 d coinciding fairly well with the synodic period of Jupiter? Could it be explained in the frame of the current knowledge about our Sun and the Solar system?

2. Period P_1, or "the other side" of the Sun

Fig. 1 shows the power spectrum of the 41-year time sequence of the solar velocity, computed by direct Fourier transform for a frequency range nearby *a priori* frequency $\nu_0 = P_0^{-1}$. Here, instead of the well known period P_0, – which has been dominant over first 9 years of the Crimean observations (in 1974–1982, – see Fig. 2, and also Brookes et al. (1976), Severny et al. (1976), Scherrer and Wilcox (1983), and Kotov and Haneychuk (2011)), – the strongest peak corresponds to a period of $P_1' = 9597.933(18)$ s; standard errors are shown in brackets. Note that the number of independent frequencies in Fig. 1 is five times larger than that in Fig. 2 (where the two sidelobes, 9597.774 s and 9603.474 s, are caused mainly by seasonal, mostly near-annual, gaps of observations).

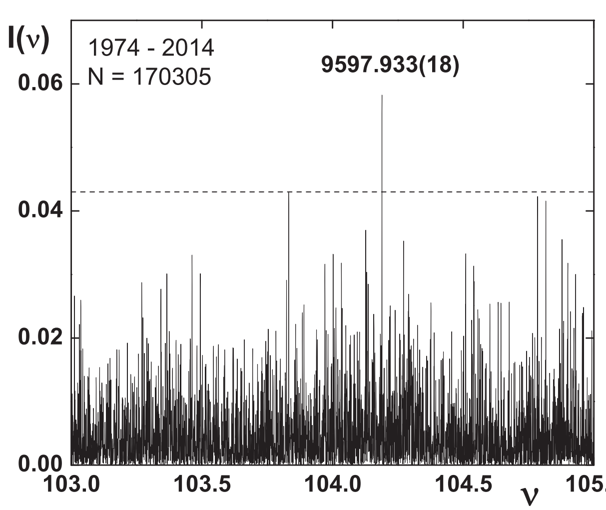

Fig. 1. Power spectrum of solar oscillations in 1974–2014 ($N = 170,305$; the dashed line indicates a 3σ confidence level, ν – frequency in μHz and power $I(\nu)$ – in arbitrary units). The main peak corresponds to period $P_1' = 9597.933(18)$ s.

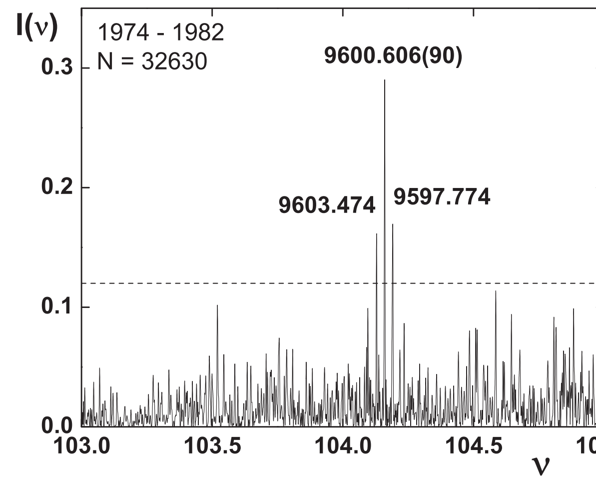

Fig. 2. Same as Fig. 1, for 1974–1982 (after Kotov and Haneychuk (2011); $N = 32,630$). The primary peak corresponds to a period of 9600.606(90) s.

The same conclusion follows from the phase diagram O–C ("observation" minus "calculation") in Fig. 3, where dots show phases φ of harmonic maxima of velocity, obtained for each successive 2-year piece of data for the test period 9597.600 s, and with a repetition for phase intervals 1–2, 2–3 etc. (An amplitude of sinusoid happened to be negligible only for intervals 1985–1986 and 1996–1997, corresponding to solar activity minima, and for 2013–2014.) One makes sure of the remarkable stability of the oscillation phase: the last three phases (dots) lie almost on the same straight line as determined by previous observations (Kotov and Haneychuk, 2011).

The slope of the linear regression line in Fig. 3 says that the true period is $P_1'' = 9597.924(11)$ s; it coincides well, within the error limits, with the above P_1'. For the most

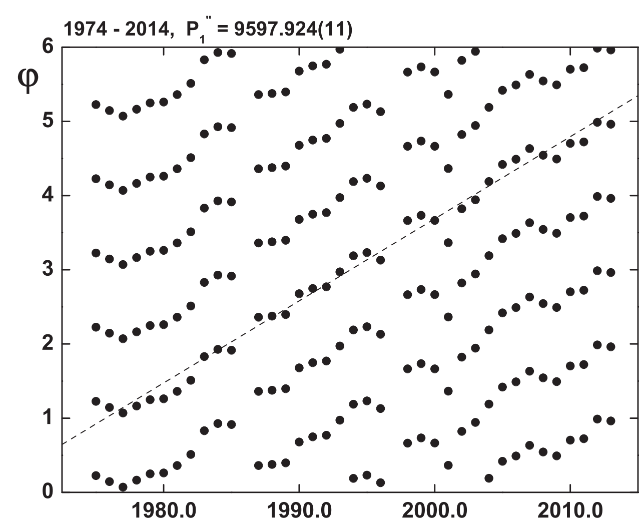

Fig. 3. The O–C diagram for the trial period 9597.600 s. On the horizontal axis – time in years, the phases φ are shown by dots, and the error bar corresponds to typical uncertainty in phase (comparable with the dot size). The dashed sloping line corresponds to linear regression, indicating a true period $P_1'' = 9597.924(11)$ s.