

Crimean observations of the magnetic Sun: 1967–2018

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ABSTRACT

The magnetic field measurements of the Sun as a star initiated by academician A.B. Severny have been supported by six other observatories. The history of such investigations at CrAO and the basic results are briefly described. The synodic spin period of the gravitating solar mass $P_{\odot} = 27.027(6)$ days is determined; the latter is shown to be linked to the Earth's motion: the Sun makes 27 semi-revolutions over one terrestrial year, and the Earth – the same number of its revolutions with the period P_D during one full solar rotation. The field changes with the Hale cycle $P_H \approx 22$ years and the cycle $P_7 = 7$ years, whereas their ratio coincides with the Archimedes approximation, 22:7, for the π number, the timescale $(\pi - 3)P_7 = P_{\odot}^2/2P_D$ – with the Earth's orbital period. We provide arguments in favour of the cosmic origin of both cycles and holographic expressions, including P_H , P_7 , π , and universal constants.

Key words: CrAO history, Sun, magnetic field, rotation, 11-year cycle

1 Introduction

For over half a century a unique experiment has been carried out at the Crimean Astrophysical Observatory: regular measurements of the Zeeman effect of the Sun-as-a-star's photosphere based on the Zeeman effect of photosphere absorption spectral lines. Measurements were carried out with the telescope BST-1 using a Babcock-type magnetograph – the Crimean solar magnetograph designed by N.S. Nikulin, applying the ideas and with the participation of A.B. Severny and V.E. Stepanov (Nikulin et al., 1958). Such solar observations performed in 1970–2020 were supported by six world observatories (see 3).

2 BST-1

The main challenges implemented with the Tower Solar Telescope (BST-1, before and/or after the reconstruction in 1970–1973 under the leadership of A.G. Pereguda and G.A. Monin; see Severny, 1955; Kotov et al., 1982) were: (1) to derive spectrograms with high spatial and spectral resolution (photospheres, spots, flares, ejections of matter, prominences, and other formations on the Sun); (2) to make sketches of spots and to measure visually – by means of the polaroid mosaic – the maximum absolute magnetic field strength of spots; (3) to photograph the solar disk in the H_{α} lines of hydrogen and K Ca II on photoplates with a double-beam spectroheliograph; (4) to measure the magnetic field based on various spectral lines; (5) through the many-hour scanning to measure the magnetic field of the whole disk, as well as the fields of poles in quiet and active regions, in

spots and prominences; (6) to measure the whole magnetic field vector in spots and active regions; (7) to explore the fine structure and magnetic field variations, brightness and line-of-sight velocity (the quiet and active photosphere, its various details – with a resolution of up to $1''$); (8) to predict flare activity (“Severny's Program” in the 60s: based on the active region magnetogram, the magnetic field gradients and the structure of electric currents were determined, and based on the structure, by invoking observations with KG-1, there was determined a possibility of strong flares throughout the oncoming three days; this was done before and during the flights of cosmonauts, aiming at warning of the radiation danger in space; the correctness is 70%); (9) since 1974 – observations of the global solar pulsations (Severny et al., 1976; Kotov, Haneychuk, 2016).

There were episodic works such as (a) spectral observations with a vacuum spectrograph (the acquisition of high-quality spectra), (b) the recording of local acoustic (“5-minute”) fluctuations of the photospheric line-of-sight velocity, (c) infrared (IR) observations, in particular, measurements of the limb darkening carried out in cooperation with the Institute of Astrophysics in Paris (IAP), (d) the recording of global solar brightness oscillations using a magnetograph or (e) a mechanical IR-modulator (with IAP), and then (f) photodiode matrices, and (g) the recording of global oscillations of the solar mean magnetic field (MMF).

After 1994, for several years the group of E. Rhodes investigated the acoustic oscillations of the photosphere by applying a magneto-optical filter. The derived data were sent to the USA, in particular, for correcting on spots and orientating the MDI device on the SOHO satellite. At the same time the group of I.A. Eganova (Novosibirsk) carried out a work

on checking the hypothetical effects of N.A. Kozyrev with a registration of mineral mass variations affected by “external irreversible processes”.

Observations with BST-1 on various programs and in different years (1965–2017) were carried out by A.B. Severny, S.I. Gopasyuk, V.I. Haneychuk, T.T. Tsap, V.A. Kotov, as well as by A.S. Andreev, O.A. Andreeva, A.N. Babin, E.A. Baranovsky, O.S. Gopasyuk, M.J. Huseynov, M.L. Demidov, L.V. Didkovsky, A.V. Dolgushin, I.A. Eganova, D.I. Irgashev, R.N. Ikhsanov, B. Kalman (Hungary), A.N. Koval’, V.M. Kuvshinov, L. Kulcsar (Czechoslovakia), S. Koutchmy (France), Li Ru-Fen (PR China), L. van Lyong (Republic of Vietnam), V.P. Malanushenko, S.I. Plachinda, D.N. Rachkovsky, E. Rhodes (USA), J. Stenflo (Sweden), N.N. Stepanian, N.V. Steshenko, P. Scherrer (USA), A.G. Shcherbakov, V.B. Yurchishin. Technical support of the telescope and instruments was provided by N.S. Nikulin, A.M. Chizhov, L.F. Bezhko, L.V. Didkovsky, I.P. Zalesov, V.I. Lopukhin, V.I. Haneychuk, as well as by A.V. Bruns, A.V. Dolgoplov, A.R. Pulatov, N.P. Rusak, D.G. Semyonov, L.N. Stukov, G.A. Sunita, etc., including the staff from CrAO manufacturing; automatization, computer, and software support was provided by N.S. Nikulin, A.V. Bukach, L.A. Granitskaya, L.V. Didkovsky, I.P. Zalesov, V.I. Haneychuk. In the following, we outline the chronology of the Sun-as-a-star observations (see also [Kotov, 2007](#)).

3 Brief history

In November 1967, Andrey Borisovich Severny came at the telescope and suggested measuring the Zeeman effect of the whole solar disk without spatial resolution. (He had just come back from the international symposium where together with R. Howard and V. Bumba discussed a possibility of measuring the Sun-as-a-star field. For this purpose, Howard averaged disk magnetograms taken at the Mount Wilson Observatory, but due to the indefiniteness of the magnetograph’s “zero”, calibration uncertainties, and other effects the errors were several gauss, thus a sought-for signal was hidden in noise.)

Severny and I directed a solar light beam from coelostat mirrors to the diagonal mirror, and then – to the spectrograph entrance slit (in such observations only flat mirrors are involved; the Sun is observed as a star or, as we said, in a “parallel beam”: the spectrograph slit is illuminated by the whole solar disk; a circular polarization degree is measured in wings of the spectral line that is sensitive to the magnetic field). If the Zeeman effect at BST-1 was usually registered based on the absorption line of Fe I $\lambda 525.0$ nm, with the Lande factor $g = 3$, then the magnetograph’s “zero” was proposed by Severny to be recorded on the analogous signal obtained from the Fe I $\lambda 512.4$ nm line, $g = 0$. The first record with a 20-minute duration for each line has shown that MMF (a longitudinal component) is measured with an error of 0.10–0.15 G, whereby with the known, almost ideal instrument’s “zero”! Such measurements were regularly carried out at BST-1 in 1968–1969, at BST-2 between 1970 and 1976 due to the reconstruction of BST-1; in 1991 these were resumed at BST-1 that is currently named after academician A.B. Severny.

Since 1967 the MMF observations at CrAO in different years were carried out by A.B. Severny, S.I. Gopasyuk,

V.I. Haneychuk, T.T. Tsap, V.A. Kotov, as well as by M.J. Huseynov, M.L. Demidov, D.I. Irgashev, and S.I. Plachinda; observational data were reduced by A.B. Severny, S.A. Bondarenko, E.I. Limorenko, G.Ya. Smirnova, N.G. Sunita, N.P. Frolova, A.V. Haneychuk, N.F. Chernykh, and V.A. Kotov.

After the first year of observations there appeared a work by [Severny \(1969\)](#) with such basic conclusions: (a) MMF may be really measured, (b) it has a sectorial structure (with signatures of two and four sectors of the same polarity per one solar revolution); then the sectorial structure of MMF was shown to agree with that of the interplanetary field ([Scherrer et al., 1977a](#)), (c) the field daily values in 1968 varied in the range from -1.5 G to $+0.8$ G, (d) spot fields do not contribute significantly into the resulting signal of MMF, and (e) the Sun is a magnetic rotator with a synodic rotation period of ≈ 27 days. (Similar observations by Severny et al. (1974) were started later at the ZTSh telescope for measurements of the weak stellar magnetic fields.)

In 1970, attracted by the novelty of this work, J. Wilcox (Stanford University, USA) visited CrAO; in the same year on his initiative R. Howard and P. Scherrer began to measure MMF at the Mount Wilson Observatory, and in 1971 Severny with his wife were the guests of Wilcox. All this affected the foundation in 1974 in Stanford of the special observatory (now the Wilcox Solar Observatory, WSO) for studying MMF, the polar field, and large-scale fields on the Sun. The observatory was comprised of a tower telescope, coelostat, vertical spectrograph equipped with a beam splitter, and a Babcock-type magnetograph. In the context of this building work, I visited Stanford in 1974 and Scherrer with his wife visited CrAO in 1975.

The Crimean measurements in 1968–1976 compiled the world’s first MMF catalogue ([Kotov, Severny, 1983](#)). In the following, we present some results of such investigations at CrAO.

4 Data of 1968–2019

Over 52 years the MMF measurements were carried out by two observatories: CrAO¹ ([Kotov, 2013](#)), Mount Wilson, WSO² ([Scherrer et al., 1977b](#)), Sayany (Institute for Solar-Terrestrial Physics, Irkutsk; [Demidov et al., 2005](#)), Saterland ([Chaplin et al., 2003](#)), the USA National Solar Observatory (NSO)³, and Kislovodsk (Pulkovo). Totally 28 thousand daily values of MMF were derived; this allowed one to accurately determine the solar rotation rate and to study the behavior of MMF with the 11-year cycle.

A list of data is given in Table 1, where N is the number of daily values of the longitudinal field strength B of the visible solar hemisphere, Δ is the typical error of an individual measurement, S is the standard deviation of the array, and k is the normalized coefficient, with the help of which data are brought together into a common series of 1968–2019 with the number $N = 27874$, $S = 0.61$ G and the average one

¹ <http://crao.ru>

² <http://wso.stanford.edu>

³ <https://solis.nso.edu>

Table 1. MMF measurements carried out at seven observatories, 1968–2019

Observatory	Years	Line (nm)	N	Δ , G	S , G	k
CrAO	1968–2018	Fe I λ 525.02	3890	0.11	0.61	1.00
CrAO	2001–2018	Fe I λ 524.71	1863	0.14	0.61	0.99
Mount Wilson	1970–1982	Fe I λ 525.02	2457	0.07	0.67	0.90
WSO	1975–2019	”	13368	0.05	0.37	1.64
Sayany	1982–2015	”	477	0.05	0.72	0.84
Saterland	1992–2001	K I λ 769.90	1988	0.01	0.43	1.41
NSO	2003–2017	Fe I λ 630.15	3536	0.01	0.45	1.35
Kislovodsk	2014–2015	Fe I λ 630.25	295	0.01	0.99	0.61
In total ^a	1968–2019	–	27874	–	0.61	–

^aNormalized data.

–0.010(4) G; spectral lines based on which the field is measured are listed in Column 3. The positive B corresponds to the north polarity, the zero phase – to the epoch 0 UT, January 1, 1968, and power spectra (PS) or periodograms were calculated by the superimposed epoch method, then by the direct Fourier transform (programs were elaborated by D.N. Rachkovsky (1985) and more improved ones – by V.I. Haneychuk).

5 Solar rotation

In 1968–1976, the two-sector structure rotated with the synodic period $P = 27.03(6)$ days, but having been supplemented with data it approached 26.92(2) days (Haneychuk et al., 2003). However, in the PS of the full 52-year series, no corresponding peak of the coherent rotation is seen, see Fig. 1.

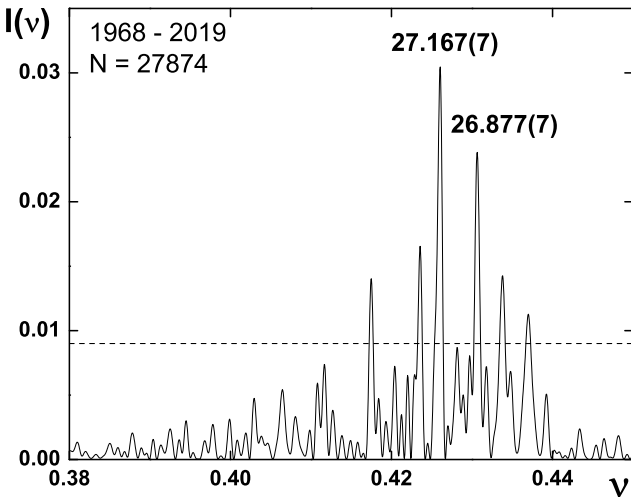


Fig. 1. Power spectrum of MMF in 1968–2019 ($N = 27874$) for the solar rotation frequencies. Horizontally – frequency ν in microhertz, vertically – power $I(\nu)$ in arbitrary units; the dashed line marks the significance level 3σ , numbers denote the period in days

To ascertain the main variation periods of MMF, there were determined amplitudes and phases φ_h of the sinusoid maximum constructed with a trial period of 27.000 days for

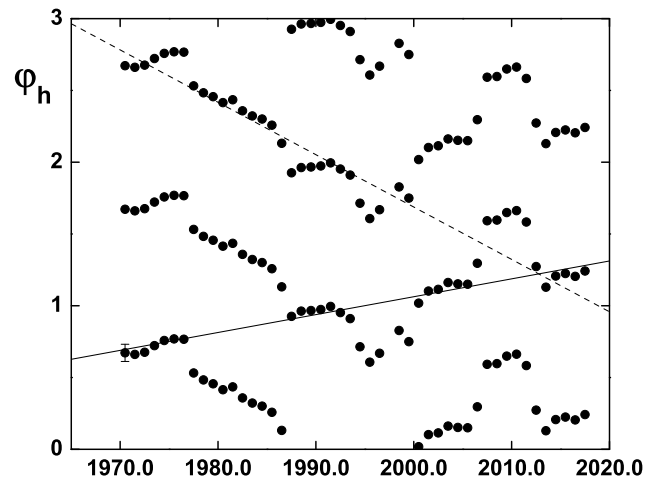


Fig. 2. O–C diagram plotted with a period of 27.000 days. Along the horizontal axis – years, along the vertical axis – phases φ_h (dots, see the text) with a recurrence for phase intervals of 1–2 and 2–3. The vertical line shows the typical phase uncertainty, and two inclined lines – regression lines that indicate an actual period of 26.927(7) days (dashed) and 27.025(4) days (solid)

each consecutive five-year data range. This resulted in the O–C diagram (Fig. 2), where the direct linear regressions are evidence for two periods: 26.927(7) days and 27.025(4) days with disturbing and restoring initial phases, which are specified by the corresponding PS (Kotov, 2019a):

$$P_{EQ} = 26.930(7), \quad P_{\odot} = 27.027(6). \quad (1)$$

The former, being consistent with a spectroscopic period of 26.94(17) days (Scherrer et al., 1980), corresponds to the equator rotation, and another one – to the rotation of the gravitating mass of the Sun as a star. The corresponding sidereal periods equal, in days:

$$P'_{EQ} = 25.081(7), \quad P'_{\odot} = 25.165(6) \quad (2)$$

(interestingly that the period of their beats, 21.1(2.4) yr, coincides within the error limits with the Hale cycle length, 22.14(8) yr). The sidereal period of the Sun as a star is seen to be in tight resonances with orbital and axial motions of the Earth: 27:2 and 1:27, respectively, see (1).

Indeed, only three timescales characterize motion of the Sun–Earth system: $P_{\odot} = 27.027(6)$ days, $P_Y = 365.256$ days, and $P_D = 1.000$ days (the latter two are orbital and axial, with respect to the Sun, motion periods of the Earth, respectively). They correspond to a pair of dimensionless parameters of more than unity:

$$\frac{P_Y}{P_{\odot}} = 13.514(3), \quad \frac{P_{\odot}}{P_D} = 27.027(6), \quad (3)$$

resulting in resonance ratios of the diophantine type:

$$2\frac{P_Y}{P_{\odot}} \approx \frac{P_{\odot}}{P_D} \approx 27. \quad (4)$$

The left part (4), which is accurate to the 0.01% uncertainty of the period P_{\odot} , reports that per year our star makes almost 27 semi-revolutions, synodic, whereas the Earth per one solar revolution makes the same number of its axial rotations with respect to the Sun. This is suggestive of a hidden association between motions of the Sun and the Earth: the day and year durations are interrelated; this may be triggered by, for example, coherent fluctuations of gravity inside the Solar system (a topic of future investigations)

On the basis of (3) for the synodic period of solar rotation, we have in days

$$P_{\odot} = (2P_Y P_D)^{1/2} \approx 27.028 \quad (5)$$

that is consistent with the observed value 27.027(6) days. (A question remains open as to whether the Moon is moving randomly with a sidereal period of 27.322 days, which is close to commensurability with P_{\odot} .)

Thus, with respect to the far stars, the Sun rotates with periods $P'_{EQ} = 25.081(7)$ days; this corresponds to the rotation rate of matter and field at the equator (the correspondence evidently reflects the field freezing-in into the plasma), and $P'_{\odot} = 25.165(6)$ days – for the whole Sun. However, from the Earth we record an equatorial period of 26.930(7) days, a half of which, 13.465(4) days, coincides within the error limits with a period of solar “magnetic oscillations” of 13.4582(25) days – a prime coherent over decades period of the MMF 4-sector structure. This value agrees well with a dynamical, or resonance, scale of 13.4577(10) days of the planetary system (the scale appears to have a gravitational nature; Kotov, 2018).

On the basis of (5) for the theoretical orbital period of the Earth, we obtain in days

$$P_Y \approx \frac{P_{\odot}^2}{2P_D} = 365.23(17) \quad (6)$$

that agrees with observations. But owing to Newton’s law

$$P_Y = 2\pi \left(\frac{a^3}{GM_{\odot}} \right)^{1/2} \quad (7)$$

(notation is usual, $a = 1$ a. u.), for the gravitational constant, making equal (6) and (7), we obtain

$$G = \frac{a^3}{M_{\odot}} \left(4\pi \frac{P_D}{P_{\odot}^2} \right)^2 = 6.675(6) \quad (8)$$

in units $10^{-8} \text{ cm}^3 \text{ yr}^{-1} \text{ s}^{-2}$. This agrees with a value of 6.67408(31) in Tanabashi et al. (2019) and even better – with a recent laboratory measurement of 6.67554(16) acquired by Quinn et al. (2014), as well as with a “cosmic” value of 6.67543(2) derived by Sanchez et al. (2013) from a symmetry of three fundamental interactions: electromagnetic, gravitational, and weak (and based on observations of global solar pulsations with a period of 9600.606(12) s; see Severny et al., 1976; Kotov, Haneychuk, 2016). However, agreement is lost if P_D and P_{\odot} in (8) is substituted by sidereal values; an explanation of this puzzle will be the topic of future investigations of MMF and dynamics of the Solar system.

6 Cycles of 22 and 7 years

In the low-frequency part of PS in Fig. 3, the most pronounced peaks correspond to periods $P_C = 20.4(1.4)$ yr and $P_7 = 7.12(17)$ yr (for frequencies $\nu \lesssim 0.015$ microhertz, the actual level 3σ , corresponding to the “red” noise $I(\nu) \sim \nu^{-1}$, is located above the dashed line). If the former is consistent almost within the error limits with the Hale cycle $P_H = 22.14(8)$ yr, or with the doubled Wolf cycle $P_W = 11.07(4)$ yr, then another one is of unknown nature (about other peaks exceeding the significance level 3σ see Kotov, 2019b).

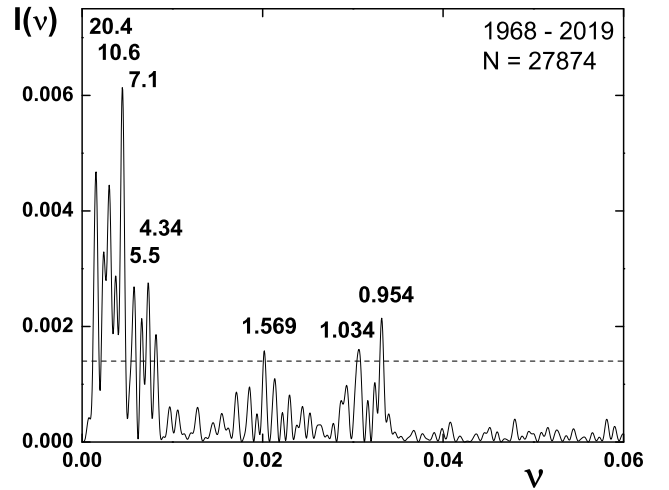


Fig. 3. Power spectrum of MMF over 1968–2019 ($N = 27874$). Horizontally – frequency ν in microhertz, vertically – power $I(\nu)$ in arbitrary units; the dashed line corresponds to the significance 3σ , and the most prominent peaks (a period in years) are denoted by numbers

The MMF variation curve with the period P_H represented in Fig. 4 has a non-harmonic profile; this stimulated a discussion of the hypothesis of the “non-solar”, or cosmic, nature of the cycle (without denying the effectiveness of the dynamo mechanism for manifestations of a cycle in the photosphere and convective zone; see Kotov and Sanchez (2017)). An average curve of the 7-year period, not outlined here, is close to the sinusoid with an amplitude of ≈ 0.08 G.

After refining this period $P_7 = 7.06(13)$ yr, particular attention is given to it: (a) the corresponding peak in PS

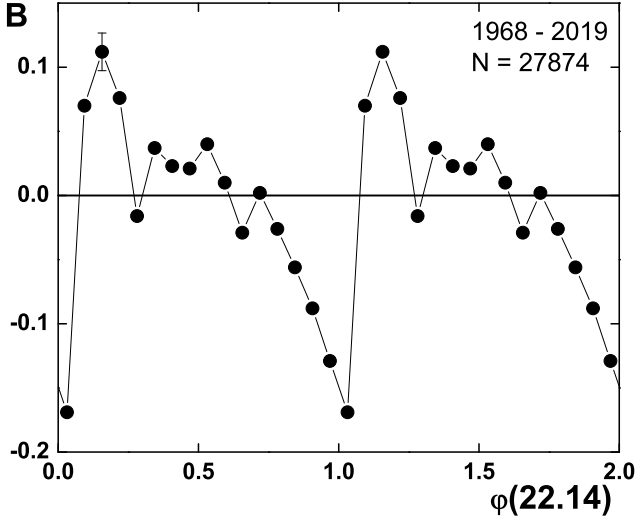


Fig. 4. Average curve of MMF variation with the Hale period 22.14 yr ($N = 27874$). Horizontally – phase φ , vertically – strength B in G; the typical standard error for each of 16 blocks of data is denoted by the vertical line

exceeds in height the peak P_C and (b) a ratio of the Hale cycle to P_7 equals 3.14(6), i.e. within the error limits is equal to the world constant π . Some periodic processes in nature are known to be related to the π number as the space geometry factor; therefore π is included, for instance, into the probability formula (let us highlight that the ratio P_H/P_7 is somewhat closer to π than to three with the difference significance 2.3σ).

The next step is an acceptance that π may characterize not only space but time, manifesting exemplarily in stability of certain periodic processes with respect to the other, more fundamental timescales, processes, and cycles on the Sun and in the Galaxy. The 7-year cycle of MMF may serve as an example with respect to P_H .

7 Cosmic nature of cycles?

The peculiar view of the curve P_H in Fig. 4 suggests that at the core of the Hale cycle (with a “one-half” value – the Wolf cycle P_W) there is a nonlinear mechanism, unlikely the dynamo mechanism, and that the very cycle is of cosmic origin. The curve of the “magnetic” cycle also confirms the Gnevyshev and Ohl rule (1948): the Hale cycle consists of two 11-year cycles, starting from the even Wolf cycle, with a smaller number of spots in maximum.

Evidence for the cosmic origin of the 22-year cycle follows from the analysis of epochs of extrema of the Wolf numbers (Kotov et al., 2012). The constancy of the initial phase – since the Galilean times – proves that not so much in solar depths a kind of “timer” is hidden (that governs, following Dicke (1978), the course of the cycle), but the very cycle is of the exogenous nature. According to Sanchez et al. (2011), the 11-year solar cycle is a reflection of some periodic property of the observed Galaxy that is relatable to the assertion “... the 11-year solar cycle is likely the most known quasi-periodic phenomenon on the Sun and may be in astrophysics at all” (Obriadko, 2008). (Let us clarify: the

most known and the most “ancient” periodic phenomena in astronomy are related to days, a year and a month, i.e. to the motions of the Earth–Moon system. It has already been shown (Kotov, 2019a) that a relation of the solar rotation with motions of the Earth, which determine duration of a year and days, – and apparently with motions of the Moon – is non-random; this makes more seriously concern the anthropic principle, see Carr, Rees, 1979; Rubakov, Shtern, 2020.)

It’s easily to find hints of the “solar” cycle on the “quantum borders” of the Galaxy. Indeed, there has recently been found a holographic relation between Hale’s length $L_H \equiv cP_H$ and sizes of the Galaxy and a hydrogen atom:

$$P_H \equiv \frac{L_H}{c} \approx 2 \frac{(a_B R_U^3)^{1/4}}{c} = 22.03(5), \quad (9)$$

in years, where $a_B = \hbar^2/m_e e^2 \approx 0.529177 \times 10^{-8}$ cm and $R_U = cT_U = 1.306(4) \times 10^{28}$ cm are radii of Bohr and the Universe, respectively, and $T_U = 13.80(4) \times 10^9$ yr is the “age” of the Universe (see Kotov et al., 2012; Kotov, Sanchez, 2017). Expression (9) cannot be perceived as a result of the numerology game since it has a simple geometrical interpretation:

$$\frac{L_W}{a_B} \approx \left(\frac{R_U}{L_W} \right)^3, \quad (10)$$

where the length of the Wolf wave $L_W \equiv L_H/2$, expressed in radii of the hydrogen atom, with an accuracy of 2% is equal to the volume of the Universe, expressed in volumes of the Wolf sphere of the radius L_W .

According to (9) for the theoretical 7-year period, we have in years

$$P_7 \approx 2 \frac{(a_B R_U^3)^{1/4}}{\pi c} = 7.01(2). \quad (11)$$

Of interest is a formal association of the Earth’s orbital period with fluctuation P_7 :

$$P_Y = (\pi - 3)P_7, \quad (12)$$

equality that is accurate to 0.04%, which is smaller than the uncertainty of P_7 ; its sense has to be figured out.

8 Conclusion

The Sun within the error limits of measurements is of a spherical shape, whereas R_\odot and L_\odot are practically invariable on the scales of months–years (weak variations of L_\odot caused by the rotation, active processes, the 11-year cycle, spots, and other formations of the photosphere are easily explained). The influence of planets on the Sun was rejected in the XXth century due to negligibility of the corresponding gravitational perturbations compared to the solar gravity. Therefore, interest is arisen to MMF variations driven by the motion of electric charges. Namely, in the course of interaction between elementary particles – for instance, electron and proton – the

effectiveness of the electric force F_e by many orders of magnitude exceeds the gravitational interaction with the force F_g :

$$\frac{F_e}{F_g} = \frac{e^2}{Gm_em_p} \approx 2 \times 10^{39}. \quad (13)$$

Therefore, perturbations from planets are able to generate significant variations of global electric current systems and, consequently, variability of MMF. And the primary reason is not only a nature of two forces, but a large difference in masses m_e and m_p , leading to a difference in corresponding deceleration forces, whereas the amplitude of effects may be strengthened due to the resonance, poor studied mechanisms.

Here we refer to the Sun as a “stellar magnet” (see Gough, 2017): the many-year observations of MMF make it possible not only to look deep into the star, but to better understand the dynamics of the Solar system. And in the context of the global solar pulsations (with a period of 9600 s of the unknown nature; see Kotov, Haneychuk, 2020), the mentioned above resonances of the Sun–Earth system, and taking into account, in particular, the theory of tidal synchronization of the solar dynamo (Stefani et al., 2019; Scafetta, 2020), it is reasonable to suggest that the model of the Sun should be improved.

The cycle P_7 may be explained ambiguously: (1) the overtone of the Hale cycle caused by the saw-edged profile shape of the latter, or (2) a source of the “hidden” cycle is deeper: P_7 is a product of the “law of three”; the very law has a fundamental character associated with the central symmetry (of the space and the Sun). Following (2) and emphasizing that P_7 is π times shorter than P_H , we treat it as a hidden period of incommensurability affected by the space geometry. Its roots apparently lie in appearance of π in the probability integral (Gorobets, 2004) because not only physical processes, but all the mathematical operations and our observations are produced in the world, having spatial symmetry.

Beats with the Hale cycle 22.14 yr of processes affected by both the cycle P_7 and the triple period $3P_7 \approx 21.1$ yr presumably lead to disruptions of coherence of the 11-year Wolf cycle and the 22-year Hale cycle, as well as more long-duration solar cycles (that lead hypothetically to the climate processes on the Earth and presumably associated with other phenomena in the Solar system). A physical mechanism of appearing the world constant π for the Sun is however to be revealed. For the interpretation of P_7 it is likely useful to invoke other solar models that are different from the standard one: the same physical object or process may be principally described by various models (for instance, photon – or a wave, or a particle). High-precision and regular MMF measurements may also provide a new key for interpreting uniqueness of the Earth and long-duration stability of the Solar system – puzzles that have not successfully been resolved by Newton, Laplace, and other titans of the past.

I gratefully and warmly keep in mind years of cooperative works and hot discussions with academician A.B. Severny, as well as with the genius engineer N.S. Nikulin and technician A.M. Chizhov (both are veterans of the Great Patriotic War; this is of special mention in the year of the 75th anniversary of the Victory and 75 years from the foundation of CrAO). I am indebted to I.A. Eganova and F.M. Sanchez (Paris) for fruitful discussions about properties of the Sun and space, the Solar system structure and

the nature of physical laws, to V.I. Haneychuk for being actively involved in solar observations at CrAO, to observers from other observatories for their MMF data and to the referee for useful comments. I thank my lucky stars for the possibility of communication with many other outstanding researchers of the Sun and the Universe, among which J. Wilcox, P. Scherrer, H.I. Abdusamatov, G. Isaak, H. van der Raay, Yu.I. Vitinsky, R. Howard, D. Gough, M.L. Demidov, E.V. Ivanov, R.N. Ikhsanov, V.M. Kuvshinov, G.V. Kuklin, P.G. Kulikovskiy, S. Koutchmy, W. Livingston, V.M. Lyutyi, D.Ya. Martynov, N.S. Nesterov, V.N. Obridko, J.-C. Pecker, L. Svalgaard, J. Stenflo, E. Fossat, H. Hill, J. Hoeksema, L.I. Tsvetkov, N.S. Chernykh, J. Staude, and others.

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