COMPARATIVE ANALYSIS OF STRUCTURES OF SOME ASTROMETRICAL AND GEOPHYSICAL OBSERVATIONAL SERIES

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ABSTRACT. Some variations of geo and solar physical parameters are known to be observed simultaneously in the Earth's dynamic parameters changes. The evaluation of the influence of solar activity upon Atmospheric Angular Momentum (AAM) and Length of Day (LOD) within the short periods is made. The similarity between the amplitude and period variations of low–frequency components of polar motion parameters and geomagnetical AA–indices is discovered too.

1. INTRODUCTION

In the spectrum of irregularities of the Earth's rotation vector there are known periodicities from several days to hundreds of years. The periodic variations in the LOD with periods from several days to one year are mainly due to the interaction of AAM with solid body, and also to the tidal potential. We have chosen three characteristics of the solar activity to evaluate its influence upon AAM and LOD: Wolf–number (W), the solar radiation flux R for wavelength $\lambda = 10.7cm$ as the indicator of ultraviolet radiation, and total geomagnetic index K_p characterising the corpuscular radiation–solar wind.
For similar research within the low–frequency components of polar motions parameters we preferred geomagnetical index AA, characterising the Earth's magnetic field variation connected with solar activity.

2. INITIAL DATA AND METHODS OF ANALYSIS

For a comparative analysis we have used the following series of observations:

- variation of the Earth's rotation velocity Δ(UTI — UTC) for the period 1978—1986, available from the BIH Annual Reports;
- Atmospheric Angular Momentum (AAM), given at 0^h and 12^h for each day for period 1978—1986, available from IERS Central Bureau;
- daily values of Wolf – numbers W, of solar radiation flux R for wavelength $\lambda = 10.7cm$ and of planetary geomagnetic index K_p for the period 1978—1986, available from Solar–Geophysical Data;
- coordinates of the Earth's pole from 1846.0 to 1988.0 [1];
- values of AA–indices of geomagnetic activity during 1868 — 1982 [2];

This series of observations were analysed by the following methods:

I.I. Mueller and B. Kołaczek (eds.),
Developments in Astrometry and Their Impact on Astrophysics and Geodynamics, 323–328.

- quasi – polinomial model for approximation [3];
- fast Fourie's transform [4];
- search for periodicities by zero – crossing of filtered time series [5];
- cosinor – analysis for the study of periodic oscillation structure [6].

3. THE RESULTS OF COMPARATIVE ANALYSIS OF DIFFERENT SERIES OF OBSERVATIONS

The table displays the spectral lines in the W, R, K_p , AAMO, AAM12 and LOD – power spectrum. The periods and the peaks of the amplitudes are stated for each spectral line. W and R spectra of the solar activities are perfectly identic and practically all periodicities of those spectra are present in oscillations of LOD and AAM [7].

TABLE. The periods and the peaks of the amplitudes in the W, R, K_p, AAMO, AAM12 and LOD–power spectrum.

W		R		K_p		LOD		AAMO		AAM 12	
Period (days)	Ampl. ms	Period (days)	Ampl. ms	Period (days)	Ampl. ms	Peruod (days)	Ampl. ms	Period (days)	Ampl. 10^{23} kg m^2s^{-1}	Period (days)	Ampl 10^{23} kg m^2s^{-1}
155	9,9	155	8,6	157	1,0	149	0,049	156	19,8	153	29,7
130	6,3	129	5,4					135	26,3	134	33,8
113	6,5	113	5,5	111	1,0	114	0,028	111	13,7	116	19,3
				96,3	0,8	99,9	0,028	99,3	17,3	98,7	19,0
						82,8	0,040	92,3	19,3	82,3	17,9
				73,5	1,0						
						69,7	0,034	69,7	18,3		
						66,3	0,038	66,1	19,3	65,8	20,5
				60,7	0,8						
						54,8	0,041	55,2	20,3	55,0	23,0
52,0	7,9	51,7	5,5	51,7	0,8	52,2	0,037	50,9	23,3	51,0	21,2
						48,5	0,033	48,5	22,9	48,3	25,4
				40,7	1,1			41,3	15,1	41,3	18,5
37,7	6,2	37,6	5,1	37,7	0,8	37,9	0,045	38,0	24,6	38,0	14,4
						34,2	0,031	34,2	16,8	34,2	16,2
32,8	5,5	32,7	4,8	33,2	0,7						
27,96	8,6	27,96	8,3			27,77	0,044				
27,03	10,6	26,86	8,3			26,90	0,040				
						22,29	0,028				

In our opinion the most correct connection is for periods P = 155, 130, 113, 52 and 38 days. Two lines only out of spectra K_p (P = 96 and 40.7 days) absent in W and R, can be identified in spectra LOD and AAM. Approximately half of the lines present in LOD and AAM do not have their match in spectra W, R and K_p.

Power spectrum of AA–indices for the period 1868 — 1982 and the Earth's pole coordinates X and Y from 1846.0 to 1988.0 were obtained by the superposed epoch method with Fourier–transformation. Since the initial series of AA–indices considerably depend on 11–year cycle, low–frequency component was removed. The Earth's pole coordinate are given at 18.26–day interval and have not undergone any additional processing [1].

Fig. 1 and 2 illustrate power spectrum of AA-indices and X- coordinates of the Earth's pole in three equal time intervals. All spectra extract a harmonic with the period $P \approx 425$—468 days. In AA-indicies spectra for the period 1868—1982 this harmonic has a period $P \sim 431$ day.
In order to find the envelope parameters of amplitudes we used the cosinor-analysis procedure, i.e. data approximation with cosinosoid through the least squares method:

$$X(t) = A\cos\frac{2\pi}{T}(t-\phi) + h.$$

The period was supposed to be known and we accepted T = 435.5 days, A — amplitude, ϕ — phase, meaning the interval in radians between a conventional zero and the maximum moment; h — a constant component.

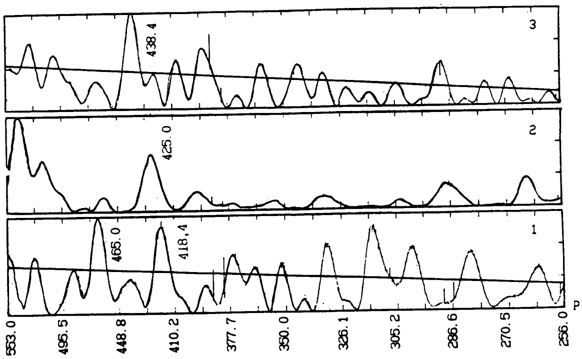

Figure 1. Power-spectrum of AA-indices for three time-intervals:
1868—1902 (1),
1903—1937 (2),
1938—1972 (3).

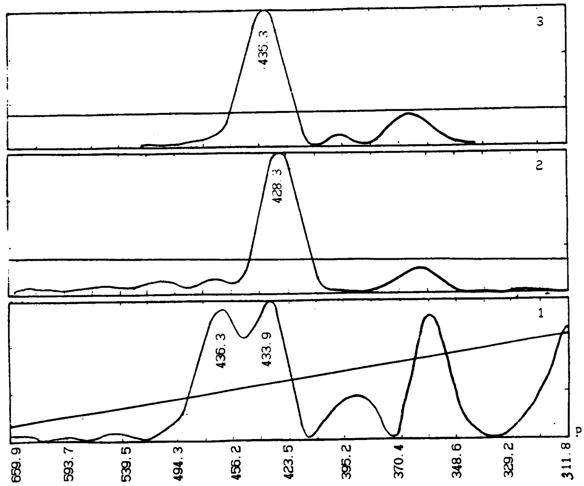

Figure 2. Power-spectrum of X-coordinate of the Earth's pole for three time-intervals:
1868—1902 (1),
1903—1937 (2),
1938—1972 (3).

Fig. 3 and 4 illustrate variations of amplitudes A and phases F of the period P = 435.5 days in the series of the Earth's pole coordinates (Fig. 3) and AA-indices (Fig. 4).
In the compared oscillation structure of the amplitudes and phases we have discovered a general minimum within the interval of 1924 — 1940.
The results of the analogue analysis for oscillation with the period P = 365.24 days are shown in Fig. 5. This picture does not show an exrteme point.

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To ascertain the oscillation amplitude minimum position and value for the period P = 435.5 days we have calculated the separate values of the period and the amplitude of Chandler's component at the medium moment of 6–year periods. These periods were shifted by a year along the time axis during the period 1846.0—1988.0 by the method of quasipolynominal approximation of the initial data [8]. The corresponding curve of the amplitudes changes is shown in Fig. 6. Having excluded high frequency component and a fixed bias using a spectral analysis method by axis – crossing we got Fig.7. The Chandler's oscillation amplitude reached its lowest value $A = 0.''0905$ in 1934. The study of the spectral composition of Chandler's amplitude change (see Fig. 6) using the method of spectral analysis by axis – crossing enabled us to extract two oscillations with probability of 0.98: the period P = 20 years and amplitude A = $0.''02$ and period P = 42 years and A = $0.''05$. The former is characterised with stability, the later in the process of numerical process modelling shown in Fig. 6 and 7, falls into two quasiharmonic oscillations with period $P \sim 30$ years and $P \sim 54$ years.

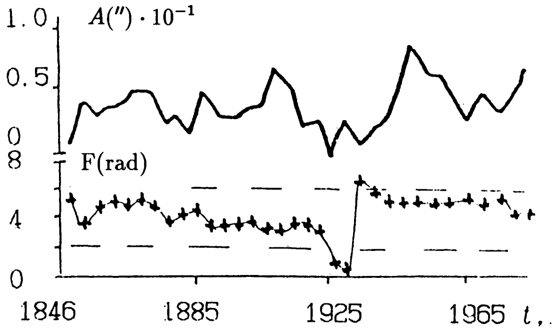

Figure 3. Cosinor–analysis procedure of the polar motion variations with the period P=435.5d. Mean amplitude $A = 0.''01019$, mean phase $\phi = 3.02 rad$.

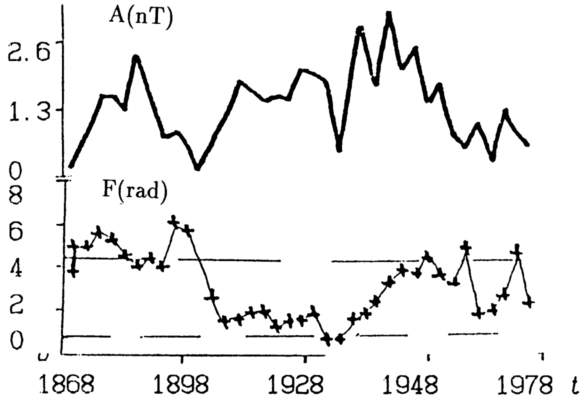

Figure 4. Cosinor–analysis procedure of the AA–indices variations with the period P=435.5d. Mean amplitude A=1.3nT, mean phase $\phi = 3.96 rad$.

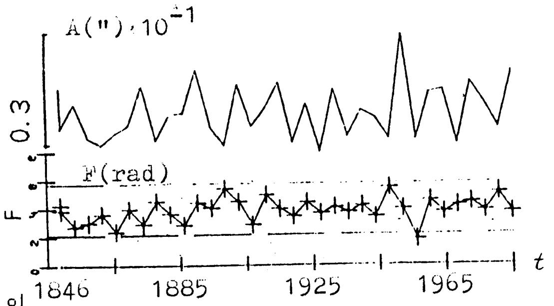

Figure 5. Cosinor–analysis procedure of the polar motion variations with the period P=365.5d. Mean amplitude $A = 0.''0073$, mean phase $\phi = 2.6 rad$.

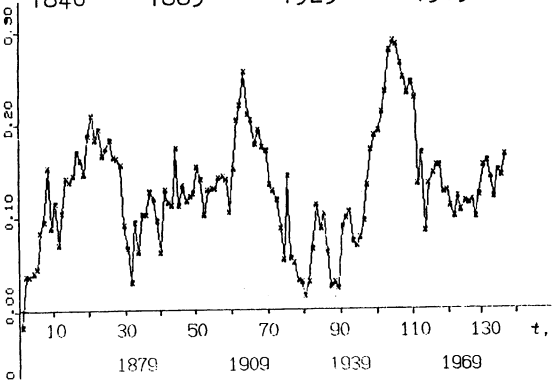

Figure 6. The variation of Chandler–wobble amplitude for the time period 1849—1985.

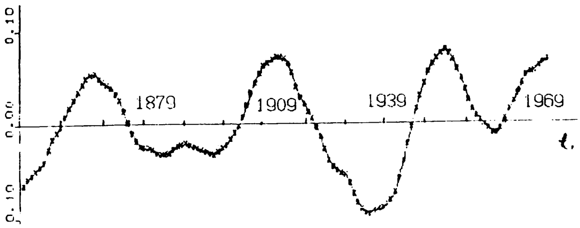

Figure 7. The low–frequency component of Chandler–wobble amplitude.

In earlier work [5] the period close to 40 years was obtained through Chandler envelope component employing Kholmogorov scholastic model.

4. DISCUSSION OF THE RESULTS

The facts shown in table 1 certify the influence of solar activity on the variation of the Earth's daily rotation speed. The sources of such influence are didcussed in [7], but the final conclusions need a further complex research of the solar activity on troposphere and atmosphere circulation. As far as the periodicity is concerned, like Chandler's one, in three AA–indices changes of the geomagnetic field , and prior to that in tiltmeter series of measurements in Finland [16], those are mere facts lacking interpretation. It should be noticed that in the structure and in the nature of amplitude changes and of Chandler's phase oscillation, the pole movement and a similar to it AA–indices oscillation (Fig. 7) enables to make a conclusion that the general minimum found in the structure of amplitudes and in the phase of the two analysed series , can be refered to the same complicated frequency phenomenon. The fact that during the 20th century there is one minimum allows the supposition of a long (100–year) period of complicated oscillations.

5. ACKNOWLEDGEMENTS

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