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PRELIMINARY INVESTIGATION OF BELGRADE LONGITUDE VARIATIONS

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1. INTRODUCTION

Tre precise determination of longitude and latitude is of practical importance, especially in geodesy, astronomy and navigation. Historians have noted that Spanish king Filip III on ascending the throne 1598., offered an award of 30 000 crowns for the practical resolution of the problem of longitude determination on sea. For the solution of the same problem in 1600. Duch offered an award of 100 000 florins (Kulikov 1962).

The identification of real longitude and latitude variations presents a hard, but very important astronomical, geophysical and geodetical task. This task is important nowadays because the increased precision and accuracy of astronomical and geodetical measurements (estimated to a few centimeters) provides the possibility of obtaining accurate perturbations of the orbital elements of artifical satellites, of identifying the local crust deformations and local anomalies in vertical deflection, etc., and of searching for its geophysical causes.

The fact that coordinates defining the position of the terrestrial station in space and on the globe vary in time imposes the need of their systematical determination.

2. SYSTEMATICAL UNSTABILITY OF THE LOCAL SYSTEM UT1 WITH RESPECT TO UT1 OF BIH

Vith the purpose of identifying the Belgrade longitude variations we analysed the residuals:

$$\xi = UT0 - UTC + x\, tg\varphi_0 \sin\lambda_0 - y\, tg\varphi_0 \cos\lambda_0 - u, \qquad (1)$$

where UT0—UTC represents the observed function, x,y—instantaneous pole coordinates with respect to Conventional International Origin (CIO), u—the difference of universal times UT1 and UTC. The values of the unknowns x, y, u computed with a resolution of 5 days, and residuals ξ for the period 1968.0—1979.0, treated in our analysis, are published in ANNUAL REPORTs of BIH.

The standard deviations of x, y, u, according to Guinot (1976), are:

$Ex = \pm 0''.013$
$Ey =$ 13 (mean values for the period 1967—1975)
$Eu = \pm 0^s.0018$.

The initial coordinates of Belgrade are:

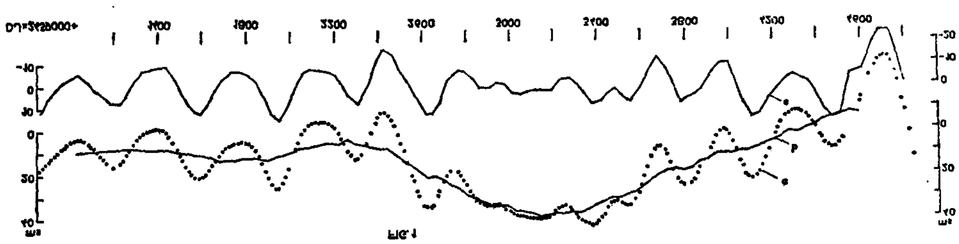
$\lambda_0 = -1^h\ 22^m\ 3^s.1905$,
$\varphi_0 = 44°48'\ 10''.354$.

In this paper the means of ξ over 15-day intervals, denoted by RT, will be treated.

Since the standard deviation of RT ($Er = \pm 0^s.0140$) is by an order of magnitude greater than Eu, the RT variations will be considered as variations of the local system of UT1 of BIH.

In order to find out what is the shape of systematical variations of RT asu function of time, which is of importance at choosing the conventent method of analysis, the smoothing of RT has been made. It is useful because great accidental errors mask systematical variations of smaller amplitudes. Accordingly, the Whitaker-Robinson-Vondrak method of smoothing (WRV) has been applied. Using the WRV method the small 55-day fluctuation of UT2-TAI, whose amplitude is under 1 ms, has been identified (Djurović 1983).

The results of smoothing of RT, denoted as RC, are illistrated in Fig. la.



As can be remarked in Fg.1, the revel of RC between the Julian dates DJ = 2441 864 and DJ = 2442 542 is relatively high and quazi-periodicall fluctuations, emphasized outside this interval, are damped.

To separate the seasonal from long-period fluctuations, the mean correction to longitude (Rm) has been computed by the Orlov's method:

$$Rm = \frac{1}{20}\sum_{i=t}^{i+4}[RC(t)+RC(t+5)+RC(t+6)+RC(t+11)] \quad (i = 0, 1, 2, \ldots) \quad (2)$$

where t represents the ordinal number of tenth of year, RC(t)—corresponding mean value of RC. Rm is referred to the epoch $t_m = t+7.5$.

By comparing x, y of BIH, IPMS and ILS we have earlier detected systematical variable differences between them (Djurović 1975). Several of these differences have periodical variations with periods close to 1.0 and 1.2 year. The effects of these errors in the system UT1 are dependent on λ_0 and φ_0. Thus, they can appear in RT.

Rm computed by the equation (2) is free of seasonal and eventual Chandlerian term.

The dependence of mean correction Rm on time is emphasized (Fig. 1b and Apendix I). The drift of Rm cannot be explained by the long propagation of accidental errors, which often appears in the moving average method. This conclusion is based on the statistical Wilcoxon's criterion.

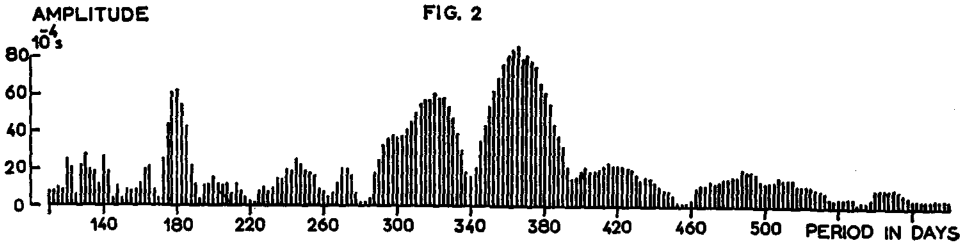
The case of the samples RC for the years A and B being homogeneous with respect to matematical expectations, is marked the figure 1 in the A row and B column of Table 1. The opposite case is marked by the figure O. Evidently, the latter case is more frequent.

The curve c in Fig. 1 represents the difference dRC = RC — Rm. As it can be seen, seasonal component of RC is perturbed.

In the spectrum of dRT = RT — Rm (Fig. 2), computed by the Fourier method, three peaks are emphasized: semi-annual, annual and 0.88-year. The last one is not well known.

The Chandler's peak does not exist.

FIG. 2



By analysing the systemytical deviations of RT for 41 observatories, and $RF = \varphi - \varphi_0 - x \cos\lambda_0 - y \sin\lambda_0 - z$for 35 observatories we have noticed that the peak near 0.8 year appears often (Djurović 1978). In the Belgrade observations its amplitude is close to the amplitude of annual and semi-annual term.

The parameters defining the three mentioned harmonic terms are:

Period	Amplitude		Phase	
Function:	dRT	dRC	dRT	dRC
0.5 year	6.1 ms	2.0 ms	182°	176°
0.9	6.0	5.7	210	206
1.0	8.6	8.1	314	350 .

The phases are related to the Julian date DJ = 2441 867 (the middle of observation interval).

From the Fig. 1 and last data it follows that the total seasonal variation of Belgrade longitude correction lies within ± 21 ms. The annual term, dependent on astroclimatic conditions, represents about a half of the total periodical variation. The second part, caused by unknown phenomena, will be interesting to our future investigations.

The mean correction Rm displays short-period fluctuations which also needs examination.

If Rm for $t \leq DJo = 2441\,444$ is considered constant and Rm for $t >$ $>$ DJo-approximated by the second order parabola, the standard deviation of residuals is $\sigma = \pm 2.5$ ms. However, if it is computed from the differences of successive Rm, $\sigma = \pm 0.9$ ms.

The main problem in the identification of small geophysical variations of longitude is presented by the unstability of non-seasonal errors of observation. In the considered interval the variation of Rm has been enormous, up to 40—50 ms. If the noticed fluctuations (three harmonic terms and the drift of RTm), which are certainly due to observation errors, are left non-explained and non-eliminated (by better thermic protection of the instrument and other precautions, for example), the identification of real longitude variation becomes impossible.

TABLE 1

Annual drift of RC estimated by Wilcoxon's criterion

	B: 1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
A: 1968	0	0	0	0	1	0	0	1	0	0
1969		0	1	0	0	0	0	0	0	0
1970			1	0	0	0	0	0	0	0
1971				0	0	0	0	0	0	0
1972					0	0	1	0	1	0
1973						0	1	1	0	0
1974							0	0	1	0
1975								0	0	0
1976									0	0
1977										0

APPENDIX I

Mean correction Rm computed by the Orlov's method

Julian date	Rm	Julian date	Rm
2439 000+		2774.3	0.0265 s
1132.6	0.0095 s	2810.9	294
1168.7	92	2847.4	318
1205.1	82	2883.8	327
1241.4	83	2919.7	346
1277.2	78	2956.6	339
1313.9	77	2993.5	344
1350.8	88	3030.3	366

1387.2	85	3066.4	370
1424.0	86	3102.4	377
1460.4	89	3139.0	393
1496.0	92	3175.8	386
1532.5	99	3212.2	375
1569.0	109	3249.2	381
1605.8	109	3285.5	370
1642.7	122	3321.9	374
1678.5	132	3357.9	361
1714.8	129	3394.5	343
1751.7	133	3431.2	325
1787.9	124	3468.0	311
1824.5	122	3504.2	304
1861.5	123	3541.5	293
1897.7	133	3577.5	282
1934.0	117	3613.3	252
1970.4	111	3650.7	220
2006.6	97	3686.8	205
2043.0	80	3723.2	186
2079.9	80	3760.1	182
2116.4	71	3796.1	189
2152.6	58	3832.1	178
2188.9	52	3868.8	151
2224.9	57	3903.9	139
2260.9	41	3940.9	115
2297.8	60	3978.3	110
2334.8	65	4014.3	111
2371.5	76	4051.1	101
2408.4	84	4087.6	101
2444.3	85	4122.9	87
2480.7	102	4159.9	74
2517.4	138	4197.6	54
2554.5	162	4234.2	39
2591.4	188	4273.8	13
2628.4	212	4311.5	17
2664.7	211	4349.6	0
2700.9	226	4387.9	— 15
2737.6	250	4426.4	— 38

REFERENCES

Guinot B.: 1976, Report presented to the Comissions 19 and 31 at the XVI IAU General Assembly, Grenoble

Djurović D.: 1975, Bull. Astron. Obs. Belgrade, № 126

Djurović D.: 1978, Publ. Dept. Astron. Belgrade, № 8

Djurović D.: 1983, Astron. Astrophys. 118

Kulikov A. K.: 1962, Variations of latitudes and longitudes, monograph., Moscou (in Russian)