SPECTRAL ANALYSIS OF LATITUDE OBSERVATIONS AT GORKY AND DETERMINATION OF THE SEMI-ANNUAL TERM OF NUTATION

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The problem of diurnal latitude variations is very closely connected with such fundamental questions as the causes of the closing sum, making more precise the coefficients of the forced nutation terms, study of the diurnal free nutation, etc.

Up to now all researchers have tried to study diurnal latitude variations through Fourier-transformed waves in the low frequency part of the spectrum using discrete time series. But such a method leads to frequency superposition or "aliasing." In such a case it is impossible to separate the frequency $(2\pi/1 \text{ day}) + \Delta\omega_j$ from $(2\pi/1 \text{ day}) - \Delta\omega_j$. Perhaps this is one of the causes of the disagreement among the results for the diurnal free nutation reported by several authors.

Complete and single-valued information on the diurnal variations of latitude can be obtained only from a 24-hour observing program. In order to study fluctuations with periods close to one day we used observations made with a Zeiss zenith telescope (D=135 mm, F=1750 mm) from 1961.5 to 1972.0 at the Gorky latitude station.

The observation program consists of two bright stars and fourteen bright Talcott pairs evenly covering 24 hours of right ascension. The zenith stars and four Talcott pairs may be observed the whole year round; the others - from six to eleven months a year. In our report we present the analysis of continuous observations of zenith stars and four bright pairs:

1. 21	3. 483	5. 555-5694
2. 907-74	4. 535-550	6. 723-742

(the stars' numbers are given according to FC4).

Analytically smoothed semi-monthly means of observed latitudes served as the initial data for the analysis. The effect of the mean

E. P. Fedorov, M. L. Smith and P. L. Bender (eds.), Nutation and the Earth's Rotation, 111–116.

latitude, its change, and low frequency polar motion were eliminated from the semi-monthly latitudes. The residual latitudes, being free from catalogue errors, contain the full sum of fluctuations with periods close to a day. In each of the six time series, nearly diurnal fluctuations are transformed into low frequency periodic components.

Figure 1 displays the power spectra of these time series. The harmonic number k and the period T in years are indicated on the horizontal axis. The ordinate is the corresponding spectral density in units of 10^{-5} computed from the equation

$$S(k) = \frac{1}{m} \sum_{\tau=0}^{m-1} \delta_k B(\tau)\left(1 + \cos \frac{\pi\tau}{m}\right) \cos \frac{k\pi\tau}{m} \quad ,$$

where $B(\tau)$ is the correlation function $(0 \leqslant \tau \leqslant n)$; $k = 0,1,2,\ldots,m$; $\delta_k = 1/2$ for $k = 0$ or $k = m$, while $\delta_k = 1$ for all other k; n is the number of semi-monthly residual latitudes in the series being analysed. The correlation function was computed for the maximum shift $\tau = 2n/3$ (dotted curve) and the maximum shift $\tau = n - 1$ (unbroken curve).

The results of the spectrum analysis definitely indicate that all the series without exception contain a semi-annual oscillation. For determination of the parameters of the semi-annual component, the residual latitudes were distributed according to argument $2\odot-\alpha$. Solving equations $\Delta\phi_t^i = a \sin(2\odot - \alpha + \gamma)$, where $\odot$ - Sun mean longitude, α - right ascension of a Talcott pair, by the method of least squares we computed the amplitude (a) and initial phase (γ). The results are shown in Table 1 and in Figure 2.

Table 1

NN	a	γ	NN	a	γ
1	0.050"±4	+25°±4	4	0.043"±4	+32°±5
2	0.048"±2	-8°±2	5	0.069"±2	+29°±2
3	0.021"±2	+7°±5	6	0.032"	+20°±3

Notice that the phases are close to zero. Presumably the semi-annual fluctuation is caused by inaccurate coefficients of the semi-annual nutation terms.

The Gorky observation program makes it possible to derive errors for the semi-annual solar nutation in terms of both longitude and obliquity components. We decided to obtain errors of not only the

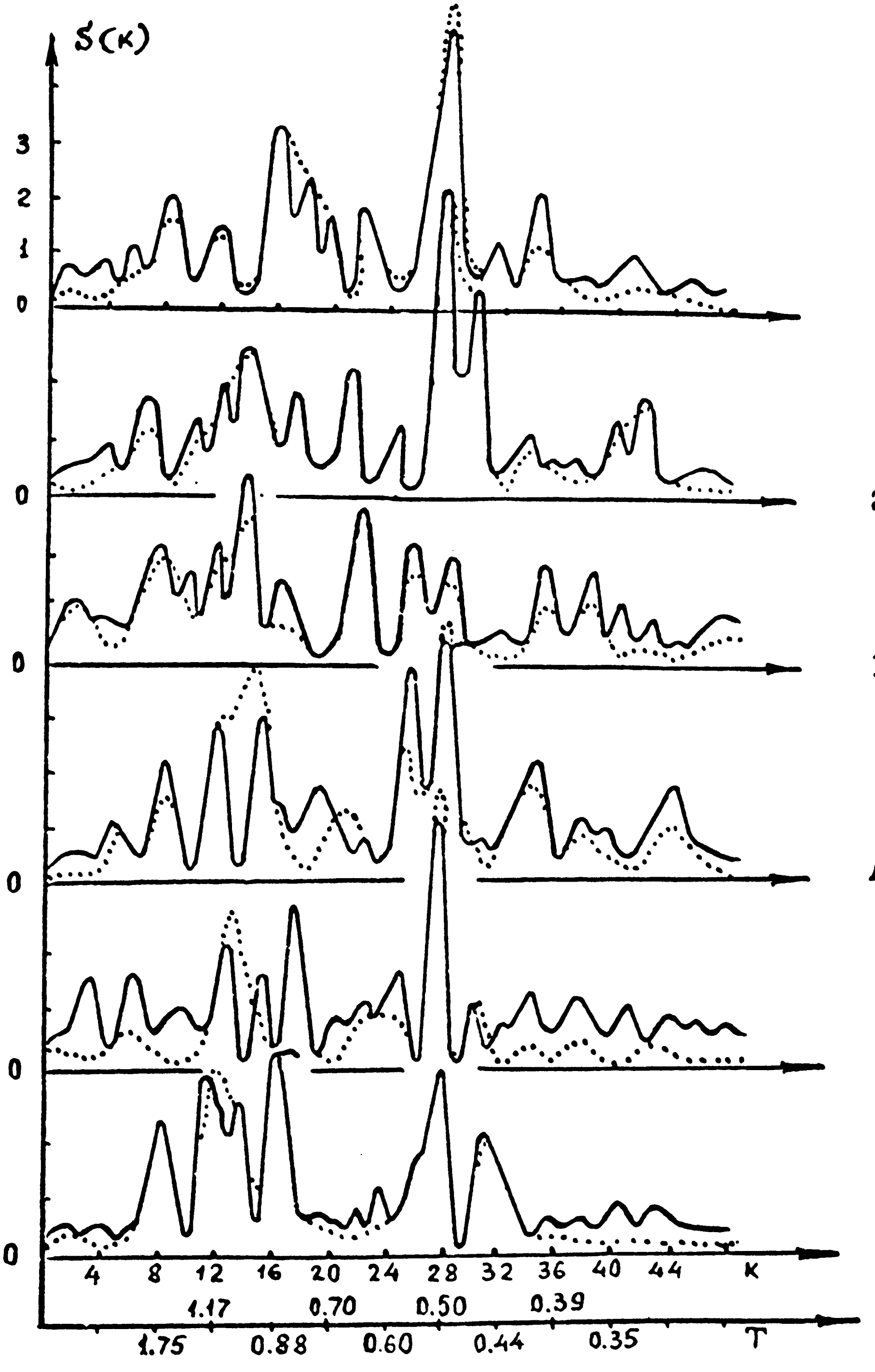

Figure 1. Spectra of Residual Latitude

https://doi.org/10.1017/S0074180900031892 Published online by Cambridge University Press

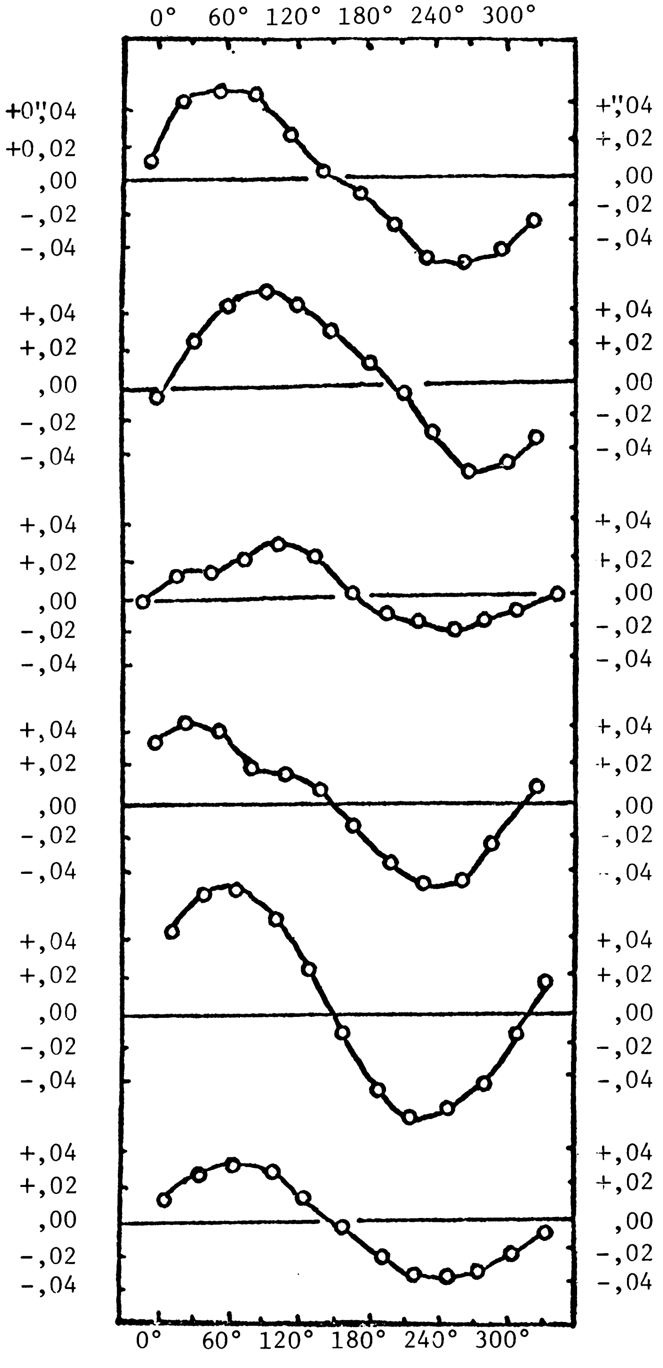

Figure 2. Semi-annual component.

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semi-annual nutation terms, but also of the annual and 1/3 annual ones. For their determination a system of conditional equations with twelve unknowns was formed:

$$\Delta\phi_t^i = a_{m,n} \sin(m\Theta + n\alpha) + b_{m,n} \cos(m\Theta + n\alpha)$$

where m = 1,2,3; n = ±1. Its solution is given in Table 2.

Table 2

Argument	$a_{m,n}$	$b_{m,n}$
$\Theta + \alpha$	0.015"	0.007"
$\Theta - \alpha$	0.015	-0.010
$2\Theta + \alpha$	0.002	-0.008
$2\Theta - \alpha$	0.035	0.016
$3\Theta + \alpha$	-0.003	-0.001
$3\Theta - \alpha$	0.012	0.004

The standard error of every derived coefficient does not exceed ±0.0025".

The first line of Table 2 should show the effect of the Earth's liquid core on the annual nutation term $(\Theta+\alpha)$:0.016" sin $(\Theta+\alpha+25°)$. Its theoretical prediction is given by the formula 0.007" sin $(\Theta+\alpha+79°)$ (Melchior, 1970). The parameters of the mean solar day term are given in the second line.

The errors in the values of the coefficients of the semi-annual terms in longitude (x) and in obliquity (y) are calculated by using only sine components. Their estimates together with the results of other authors are shown in Table 3.

Table 3

x	y	Author
0.037"	-0.033"	Kovbasjuk
0.021	-0.023	Popov
0.018	-0.022	Yokoyama

https://doi.org/10.1017/S0074180900031892 Published online by Cambridge University Press

Probably the components of $3\odot + \alpha$ and $3\odot - \alpha$ are also the effect of the fluidity of the Earth's core.

The author expresses her cordial thanks to Prof. E. P. Fedorov, Dr. Ya. S. Yatskiv, Dr. N. R. Persiyaninova, Dr. Godisov, and Mrs. Yu. M. Shur for their interest in the work and kind assistance.

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