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The Relationship between Earth Pole Oscillations and Lunar Motion

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Abstract

The variation of the Chandler and annual components of the polar motion are of a significant interest in the Earth pole oscillatory process research. Generally these variations are quasiperiodic. But some regular oscillations can be isolated from it that correspond with the basic periods of the lunar motion. Here we discuss the theoretical assumptions of the observed effect as well as the experimental rules that illustrate the relationship between the Earth pole oscillations and the lunar motion.

1. Introduction

The complex process of the Earth pole oscillations includes components with frequency and amplitude that differ significantly from each other [1]. Processing the pole motion observations over the last 100 years result in statistically convincing definition of the main characteristics in its oscillatory process. Basic components in the Earth pole motion are: Chandler wobble with 0.20'' - 0.25'' amplitude and period 430 – 440 sidereal days; and annual oscillation with 0.07'' – 0.08'' amplitude and one year period; and also polar motion's trend. Observed Earth pole oscillations have a wobbling character. The trajectory of the pole on the Earth surface is a winding and unwinding spiral with a period of about six years.

Actual problem that was stated by P. Melchior [2] about the instability in the basic components parameters of the Earth pole is still not sufficiently explored. This problem is connected with the exploring the celestial-mechanics' and geophysical causes of such behavior in the Chandler and annual components, and also with the construction of the refined models of the forecasting the Earth orientation parameters for long time intervals.

Here along with the common methods of the separating the pole oscillation process into the Chandler and annual components we suggest an approach to the resulted Earth pole trajectory research. For the purpose of analyzing the nonstationary resulted pole motion a perturbed trajectory is isolated. For the unperturbed trajectory a "mean" one is chosen – the Earth pole trajectory where the Chandler and annual oscillation parameters have mean values.

The differential equations for the amplitude a and phase ψ of the Earth pole modulation motion can be derived from the dynamical Euler–Liouville equations of Earth motion around its center of mass:

$$\dot{a} = \frac{m_E R_E^2}{A^*} r_0 \left[-2c_{22}^* \frac{C^*}{B^*} a \sin 2\psi + \right.$$
$$\left. + 2c_{22} a \sin 2\psi + s_{21} \cos\psi + c_{21} \sin\psi \right] \quad (1)$$
$$\dot{\psi} = -N_q \cos^2\psi - N_p \sin^2\psi +$$
$$+ \frac{m_E R_E^2}{A^* a} r_0 \left[c_{21} \cos\psi - s_{21} \sin\psi \right]$$

Here, A^*, B^* and C^* are the effective principal central moments of inertia accounting the Earth's "frozen" figure deformations; c_{2m}, s_{2m} are the second order coefficients of the potential expansion into a series of spherical harmonics; r_0 is the mean axial rotation velocity of the Earth; and the coefficients N_p, N_q are the quantities with close values that determine the frequency of the Chandler wobble.

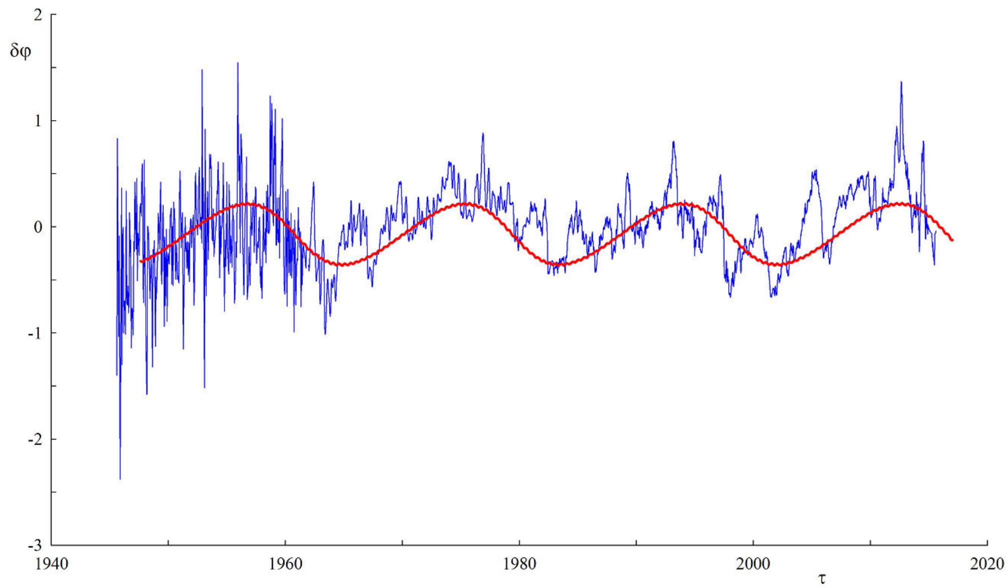

Figure 1: Synchronous oscillations of the polar motion phase (blue line) and the drift of the intersection points between the lunar orbit and celestial equator (red line).

It is shown that the significant impact into the variations of the basic pole oscillation components is given by the long-term perturbations from the lunar orbit (figure 1). The analysis of these perturbations is held using the wavelet and Fourier transformations. On the long time interval it shows matching phases of the perturbed polar motion and the lunar orbit motion using the available series of observations C04 and C01 from the International Earth Rotation and Reference Systems Service. This feature can be used to refine the model of the forecasting the Earth pole oscillations. And taking into account these structural features of the oscillations the refined numerical-analytical model of the Earth pole motion is presented.

2. Summary and Conclusions

Thus here the graphical correspondence between the Earth pole oscillations and the motion of the lunar orbit is presented. It is shown that the refined model gives a more accurate description of the Earth pole motion by comparing the model computation results with the observations made by the International Earth Rotation and Reference Systems Service.

References

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[3] Yu. Markov, V. Perepelkin, A. Filippova: Analysis of the Perturbed Chandler Wobble of the Earth Pole, Doklady Physics (in press).