FORCED NUTATION AND IRREGULARITY OF THE ROTATION OF THE EARTH

G. P. Pilnik
Sternberg Astronomical Institute
Moscow, U.S.S.R.

It is possible, in principle, to derive from astronomical observations both the tidal and nutational variations in the rotation of the Earth. However, in practice there are a number of difficulties. To detect the waves with periods of 18.6, 1.0 and 0.5 year one could use UT1-TAI. Unfortunately, this is impossible because of the lack of sufficiently long series of observations and because of significant non-periodic irregularities in the rate of the Earth's rotation. In addition, the annual wave consists of several harmonics of different natures which cannot be separated from one another. Investigation of short-period nutations is more promising, but it is also connected with specific difficulties.

Let $y(t)$ be a set of astronomical observations and $s(t)$ be the tidal variation in the Earth's rotation. Then the fundamental equation is

$$y(t) = s(t) + v(t) \tag{1}$$

where $v(t)$ represents the random errors. Assuming that nutation is taken into account correctly in the reduction of astronomical observations, we obtain $s(t) = kx(t)$, where k is the Love number and $x(t)$ is the theoretical function of the tidal variation in the rotation of the Earth. Solving the equation

$$y(t) = kx(t) + v(t) \tag{2}$$

we get the Love number k. This method was used by Guinot (1974) and Pilnik (1975,1976). To get the function $y(t)$, residuals

$$O - C = U_* - U$$

were utilized. They were obtained in the process of computing the definitive system of Universal Time. It was found, using (1) and (2), that $k(M_f) > k(M_m)$. This result suggested further investigation of short-period nutations.

It is possible in the case of an elastic Earth that the difference $y(t) - kx(t) = v(t)$ contains nutation terms. Then the solution of the

E. P. Fedorov, M. L. Smith and P. L. Bender (eds.), Nutation and the Earth's Rotation, 235–237.
Copyright © 1980 by the IAU.

https://doi.org/10.1017/S0074180900032101 Published online by Cambridge University Press

problem becomes more complicated. In such a case the Love number k should be derived from observations of some other kind. Although observations of the Love numbers have been going on for more than a half-century, an accurate value of k for the whole Earth cannot yet be given. Using the tidal variations in the rotation of the Earth we have obtained several times the value: k = 0.300. However, as is shown in Pilnik (1976), this value should be diminished by about 12% due to the effect of the ocean tide. In the future we are going to use different values of k ranging from 0.24 to 0.32 to exclude the tidal variations in the Earth rotation from the system of y(t). The true value of k seems to be somewhere in this range.

The first determination of the short-period nutation was made with k = 0.300 (Perzev and Ivanov, 1975). The main drawback of this work is that the value of k was derived from the same observations. The series of observations covering 22 years is not sufficient to separate the nutation terms with nearby frequencies. Extension of the series of observations not only would make separation possible but also would diminish the effect of random errors. Application of new electronic methods for studying the Earth's rotation looks very promising. However even the most precise methods will need very long time series for separation of the short-period nutation terms with nearly the same frequencies. In this case, for some time, the classical observations will retain their advantage.

Unfortunately, these observations are not properly organized. To obtain the function y(t) one may use Standard Time from 1951 (BEV, 1951-1974) or the data of the BIH from 1968 (BIH, 1968-1975). However in the Bulletins (BEV, 1951-1974) the differences U_*-U are given with an accuracy of $0^s.001$. The corrections for tidal deflection of the vertical are not taken into account. Besides, since 1975 the BIH definitive system of Universal Time has been calculated by a new method. Hence there is a need for additional investigations (Mezhduvedomstvennaja ..., 1975). In BIH (1968-1975) the residuals are given with an accuracy of $0^s.0001$. Starting from 1972 corrections for the deflection of the vertical have been taken into account. But the duration of these most valuable observations is not quite sufficient for the study of the short-period nutations. It is to be emphasized that the repeated changes in the methods of deriving the Universal time system considerably hamper the study of scientific problems. Such changes should be made only after thorough consideration of the problems which are now to be solved on the basis of the Universal time. The investigation of the Earth tides and nutation utilizing the astronomical observations of time would be effective only if the moments of star transit and short-period nutations are given with an accuracy of $0^s.0001$-$0^s.00001$. Some new requirements of the time service should be taken into account when creating the FK_5.

For the study of tidal and nutation terms with annual periods, it is not so important to increase the number of decimal places. But there

https://doi.org/10.1017/S0074180900032101 Published online by Cambridge University Press

are some other difficulties that cannot be overcome. The following harmonics with annual periods are superimposed in the system UT1-TAI: atmospheric, tidal, and relativistic effects; the effect of $\Delta\alpha_\alpha$ errors in star positions; the errors of the adopted aberration; etc. Even if we succeeded in deriving and allowing for the effect of atmospheric circulation on the Earth's rotation, the study of the remaining harmonics would still be impossible. In this connection, organizing the computation and publication of the observations of the International Time Service according to hour groups becomes the most important task. This seems to be the only way that would enable the effect of the errors of star coordinates on Universal Time to be estimated and then taken into account.

References

Guinot, B.: 1974, Astron. and Astrophys. 36, 1.
Pilnik, G.P.: 1975, Astron. Zhurn. 52, 178.
Pilnik, G.P.: 1976, Astron. Zhurn. 53, 889.
Perzev, B.P. and Ivanov, M.V.: 1975, Izv. AN SSSR, Fizika Zemli 7, 3.
Bull. Etalonnoe Vremja za: 1951-1974.
Bureau International de l'Heure, Annual Report: 1968-1975, Paris.
Mezhduvedomstvennaja komissija edinoj cluzhby vremeni pri Gosudarstvennom komitete standartov Soveta Ministrov SSSR. Bulleten' E-1 Vsemirnoje bremja: 1975, January-March, Moscow.

https://doi.org/10.1017/S0074180900032101 Published online by Cambridge University Press