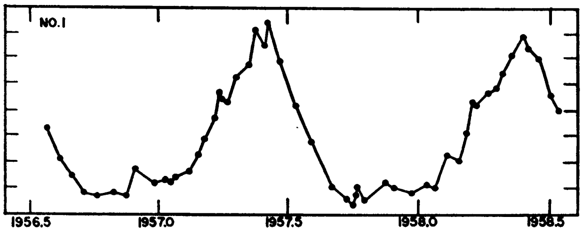

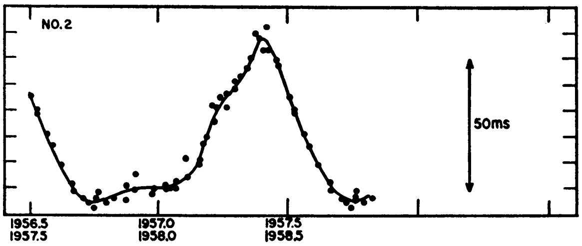

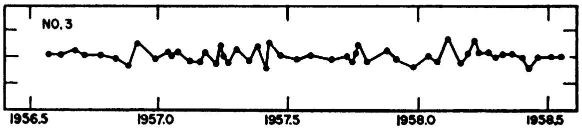

Figure 1. Variation saisonnière observée, 1956, 5 à 1958,5.

Figure 2. Courbe annuelle périodique déduite de deux années d'observation avec la représentation en millisecondes $213\theta + 93\theta^2 - 28\theta^3$ ($\theta = t - 1957{,}0$) pour la variation lente.

Figure 3. Représentation des écarts.

saisonnière est périodique, c'est-à-dire que les courbes relatives aux intervalles 1956,5–1957,5 et 1957,5–1958,5 sont superposables.

Il était peu vraisemblable qu'une telle décomposition fût possible. Or la solution du problème a été obtenue sans aucune peine. Les valeurs trouvées pour les 3 constantes arbitraires sont, en millisecondes:

$$b = +213 \quad c = +93 \quad d = -28.$$

La courbe qu'on obtient alors pour la variation saisonnière est assez différente de celle que d'autres auteurs ont publiée. La différence s'explique notamment par l'emploi du catalogue déduit par Guinot des mêmes observations.

Les valeurs individuelles étant groupées en moyennes, à raison de 2 par mois environ, l'écart–type d'une moyenne est:

$$\sigma = 2{,}5 \text{ ms.}$$

La représentation graphique des écarts ne fait apparaître aucune marche systématique.

Ainsi, les résultats de 2 années d'observation sont correctement représentés à l'aide de 3 constantes et d'une courbe annuelle empirique. Ce fait est remarquable et il correspond très probablement à une réalité physique.

L'amplitude totale de la variation annuelle est de 64 ms. Le maximum de mai est très aigu. peut-être même anguleux. Il s'est produit en 1957,41 et en 1958,41.

La courbe de la variation saisonnière ne peut être représentée par la somme de deux termes sinusoïdaux, l'un annuel, l'autre semi-annuel, même en première approximation. Les termes de période 0,25 et 0,20 sont importants. L'emploi de la méthode d'Orlov pour déterminer la variation progressive ne parait pas indiqué en pareil cas.

THE INFLUENCE OF SYSTEMATIC ERRORS OF STAR CATALOGUES ON THE DETERMINATION OF THE IRREGULARITIES OF THE EARTH'S ROTATION

By A. A. NEMIRO and N. N. PAVLOV
Pulkovo Observatory, Leningrad, U.S.S.R.

Abstract. In order to lessen the influence of the errors in the right ascensions of stars of fundamental systems on the results of time determinations, it is proposed that the results of time services observing with transit instruments be used for the determination of an independent system of right ascensions of stars. The participation in this work by a maximum number of observatories of different countries is desirable.

A detailed study of the irregularities of the earth's rotation is of great scientific interest and became possible after the present-day extremely high precision of measurements of time had been attained with the help of quartz and atomic clocks. The solution of this problem requires first of all a considerable increase in the precision of astronomical time determinations and a thorough exclusion of their errors, especially systematic.

An important source of such errors are the systematic errors of the star catalogue. The majority of time services are located in comparatively high latitudes of the Northern hemisphere and more than half of them between the latitudes 50° and 60°. It is just for this zone of declinations that the $\Delta\alpha_\alpha$ systematic errors of the FK3 are extremely large (Pavlov 1951; Nemiro 1958b; Nemiro and Pavlov 1956;

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Afanasyeva 1957) and therefore noticeably distort the system of Universal Time (UT) derived on the basis of astronomical observations of time services (Nemiro 1958b; Nemiro and Pavlov 1956; Konstantinov 1955; Smith and Tucker 1953; Heide 1952).

In the near future, after the publication of the new fundamental system of star positions—FK4—this state of conditions will be improved considerably. However, it must be noted that in spite of the indisputably high quality of the new fundamental system—FK4—there is no hope that the conditions will be completely satisfactory. Actually during the past years the precision of time measurements with the help of clocks has increased much more rapidly than the precision of astronomical observations. Especially slow has been the increase in the precision of absolute catalogues which serve as a base for the compilation of the reference system of star positions. This is connected with the somewhat slow progress of the technique of meridian observations, the most conservative branch of astrometry. Besides, the compilation of a fundamental reference system is very complicated and, to a certain extent, a problem open to discussion, needing many years for its completion. Therefore the difference between the time of publication and the mean epoch of observations is about twenty to thirty years.

It is well known that the star coordinates referred to the mean epoch are of maximal precision. It follows that when using the fundamental system we in fact refer to observations made some tens of years ago and naturally they are not of the precision which could be attained at present.

The fact that the greatest possible number (some tens) of separate catalogues are used for the derivation of the fundamental system does not save the situation as many of these catalogues are not of high accuracy and have large systematic errors. The assignment of weights to the separate catalogues is an especially controversal and complicated problem. Practice shows that the precision of fundamental systems, derived on the basis of a very limited number of the best catalogues, is not inferior in some respects to a system derived on the basis of a maximal number of catalogues. For example, Eichelberger's Catalogue (for 1925) with respect to the errors $\Delta\alpha_\alpha$ and Pu $\alpha 1$ with regards to the errors $\Delta\alpha_\alpha$ and $\Delta\mu_\alpha$ are better than the FK3 in the Northern declination zones.

Therefore it can be noted that while there is a sharp increase in the precision of time measurements with the help of atomic clocks and a noticeably increasing precision in the determination of time with photographic zenith tubes, Danjon's prismatic astrolabes and photoelectric transit instruments, the precision of fundamental catalogues is a hindrance in the solution of the problem.

What is the best possible way out of such a situation?

The simplest is the smoothing of the right ascensions of the observed stars on the basis of observations made at a time service. This is already being done during the reduction of observations made with the P.Z.T., where stars of the magnitude 9 to 10 are used. The right ascensions of these stars are found as a result of the smoothing of data of observations with the P.Z.T. An analogous process is possible for observations with transit instruments, which are used by most of the time services. An essential circumstance in this case is that the stars of the fundamental system will be smoothed. Therefore it will be possible to utilize the observational results of time services for improving the fundamental reference system.

This means, first of all, a considerable increase in the amount of observational data which will be used for the derivation of the fundamental system of right ascensions of stars. If we consider that 77 catalogues were used for the compilation of the FK3 and suppose that all the FK3 stars were included in these catalogues and that each star was observed eight times for each catalogue, then we find that each star was observed 626 times. The latter number is probably greatly overestimated. On the other hand, the Soviet time services alone, which altogether have 18 transit instruments, if observing a common list of stars, could on the average make 20 observations of each star per year with each instrument. Therefore during two years, $20 \times 18 \times 2 = 720$ observations of each star could be made and more observational data obtained than those used for the compilations of the FK3. Besides, the precision of observations with transit instruments of time services can considerably exceed, with regard to systematic and accidental errors, those made with large meridian instruments. Thus the results of observations of time services can be used very effectively for improving the fundamental system of star positions.

It should be pointed out that the observations made with transit instruments are especially suitable for the improvement of the system of right ascensions of the fundamental catalogue with regard to the individual positions of separate stars as well as the systematic errors (with the exception of the equinoxial error). We would like to point out that the compilation of catalogues on the basis of photoelectric observations of the Pulkovo Time Service gave very satisfactory results (Pavlov 1951; Afanasyeva 1957).

Observations made with photographic zenith tubes are less suitable for improving the fundamental catalogue although they can also give a well smoothed system of right ascensions for the stars of the observing list. A complication met here is that all the stars are situated in a very narrow declination zone and besides, these stars as a rule are not included in fundamental catalogues. Therefore their utilization for the improvement of fundamental systems necessitates additional observations with meridian circles, which in the given case can hardly give results of the highest precision as the azimuth of the instrument must be determined by stars in a different declination zone.

The situation is somewhat better if observations with prismatic astrolabes are used. In this case, although the process is more complicated than that for transit instrument observations, the fundamental system can be improved in a comparatively wide declination zone, about 50°, the precision being the highest in the central part of the zone.

It must be acknowledged that the transit instrument is the most convenient for improving the system of right ascensions of the fundamental catalogue. It enables an improvement of the reference system in a very wide declination zone with about equal precision for different parts of the zone.

A serious objection to the wide application of transit instruments for the time service is the relatively low precision of time determinations in comparison to that of photographic zenith tubes and prismatic astrolabes.

We assume, however, that this objection can be overcome by a transit instrument of a new design with hermetically sealed pivots, by a more precise determination of the inclination of the axis and the photoelectric registration of the moments of star transit. Such an instrument is at present being constructed in the shops of the Pulkovo Observatory. We hope that in the circum-zenith zone it will give the same precision of time determinations as the photographic zenith tube. A special construction of the pavilion is of great importance for increasing the precision of the results of observations. Ventilators should be used so as to ensure a thorough ventilation. Meridian marks are also essential in this case. They are especially necessary if the results of observations of time services are to be used for improving the fundamental system of right ascensions of stars, as it is very important for the solution of this problem that the observations made during one night be of several hours duration.

At present the propositions outlined here can be fulfilled by the collective efforts of several time services. The greater the number of time services taking part in this work, the more rapid and more precise the results. International cooperation is very desirable.

In brief, our propositions may be stated as follows: that the organization of time determinations with transit instruments of time services be such that they give a possibility of deriving the accidental and systematic errors of the right ascensions of the stars of the fundamental catalogue with maximal precision. This can be achieved for example if the chain method of observations proposed by Nemiro (1958a) is applied. We point out that this method makes possible the exclusion of the systematic errors of the catalogue from the results of time observations. It is then unnecessary to wait for the completion of the final discussion of a large number of observations made by time services. It is also possible to apply the simpler and less laborious method proposed by N. N. Pavlov (1958).

It should be noted that the method of smoothing star declinations has been used for a long time in latitude work. This smoothing gives good results because the observations made with zenith telescopes are of very high precision. This is necessary as the declinations of the faint stars used in the Talcott method are influenced by large errors.

Both of these circumstances—the high precision of observations and the large coordinate errors of the observed stars—are also present in time service work and they predetermine the expediency of smoothing the right ascensions of the stars by observations.

The use of observations of time services for improving the system of right ascensions of the fundamental catalogues proposed here and the increase on this basis of the precision of astronomical time determinations, should, in our opinion, be carried out simultaneously with the organization at several time services of parallel observations with photographic zenith tubes, impersonal astrolabes and transit instruments. However, we do not deem it expedient that all the time services observe only with zenith tubes or only with impersonal astrolabes since each of these instruments is characterized by its own specific errors and since at the same time there are still possibilities of increasing the precision of transit instruments.

Taking into account the above stated, the Pulkovo Time Service proposes in the near future to base its work on observations with photoelectric transit instruments and a photographic zenith tube.

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VARIATIONS IN ROTATION OF THE EARTH, RESULTS OBTAINED WITH THE DUAL-RATE MOON CAMERA AND PHOTOGRAPHIC ZENITH TUBES

By WM. MARKOWITZ
U. S. Naval Observatory, Washington, D. C.

Abstract. Comparison of photographic zenith tube (P.Z.T.) observations with time derived from quartz-crystal clocks during 1951 to 1955 and with cesium standards of frequency during 1955 to 1958 indicates that the seasonal variation is nearly the same from year to year. Lunar-tidal inequalities of semi-monthly and monthly periods with amplitudes of about $0^s.001$ each were found. A preliminary value of the Love number, k, is derived. Observations made since 1952 with the dual-rate moon position camera are used to derive $\Delta T = \text{ET} - \text{UT}$. Comparison of the P.Z.T. observations and atomic standards at the National Physical Laboratory and the Naval Research Laboratory shows details of the irregular variation from 1955 to 1958.

1. *Introduction.* As is well known, there are three types of variation in speed of rotation of the earth—secular, irregular, and periodic. Although the general nature of these variations has been known for some time, there is a need for determining them in detail.

Variations in speed are determined by comparing Universal Time (UT), which is based on the rotation of the earth, with time based on some other standard. This may be the moon, quartz-crystal clocks, or atomic standards of frequency. Studies of the variation in speed of rotation made at the U. S. Naval Observatory have been based on observations for UT made with the photographic zenith tubes (P.Z.T.'s) at Washington, D. C., and Richmond, Florida, and for Ephemeris Time (ET) with the dual-rate moon position camera at Washington. The clocks used have been the quartz-crystal clocks of the Naval Observatory and of the National Bureau of Standards, and the cesium standards of the National Physical Laboratory, Teddington, and the Naval Research Laboratory, Washington.

The problems treated here concern the stability of the seasonal variation, the determination of the lunar tidal variation, and the determination of the irregular variation. The results obtained permit a comparison to be made between variations in speed determined from astronomical observations and those computed from geophysical and meteorological considerations. A preliminary, but independent, value of the Love number k is obtained, and the nature of the irregular variations is shown.

2. *P.Z.T.* The cesium standards are stable to about 1 part in 10^{10}. This stability is so high that for all practical purposes the precision with which changes in speed of rotation of the earth can now be obtained depends entirely upon the accuracy with which UT can be determined. The P.Z.T.'s are well suited for the determination of UT. The instrument is impersonal, the zenith is automatically defined by a basin of mercury, and no instrumental corrections for azimuth, collimation, or level are required (Markowitz, in press). Observations are made at the zenith, where refraction anomalies may be expected to be a minimum. An important advantage of the P.Z.T. in the study of periodic variations in speed of rotation is that the system of star positions used is made internally consistent from the P.Z.T. observations themselves.

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