DETERMINATION OF NUTATION AND PRECESSION BASED ON OBSERVATIONS WITH THE PULKOVO POLAR TUBE

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Abstract. Since 1953 regular observations have been carried out with the polar photographic tube (PT) of A. A. Mikhailov at Pulkovo, a fixed astrograph (D = 200 cm, F = 600 cm) which can take photographs of a circumpolar zone of 60′ radius. An analysis of measured polar distances of the same 30 stars on each plate gives corrections to the adopted values of coefficients of the nutation and precession constant. Though several papers have appeared during the last decade in which VLBI and LLR observations were used for the determination of the nutation coefficients and precession constant, the results from a 40-year series of observations with the PT are of interest, because of its two-times period of the principal nutation term. The method is fully independent.

1. Nutation

During the period 1953–1993, 868 nights of observations were obtained and 9799 polar distances of stars with a mean error of $\pm 0\farcs05$ were measured. These were reduced according to the method given in Bakhrakh (1971). Since 1975 we stopped to determine the semi-annual and the fortnight nutation terms because of uneven distribution of observations during the year: we have no observations in summer owing to twilight and few in winter owing to cloudy weather. Thus, we determined the correction to the principal nutation term.

The value of the principal nutation constant derived, based on 1953–1993 observation series, is $9\farcs1998 \pm 0\farcs0054$ for J2000. epoch. The adopted value is $9\farcs2025$.

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2. Precession

In 1946, Wright suggested to evaluate the precession constant from measures of the proper motions of stars relatively to extragalactic nebulae. He proposed that the precession constant can be independently determined from photographs of the polar zone (Wright, 1950). When positions of the pole refer to nebulae, the polar motion thus obtained will reflect precession motion. Wright pointed out three reasons which might have an influence on the result:

1. possible instability of the telescope,
2. amount of nebulae in the polar zone,
3. the polar zone being a small part of the celestial sphere, the duration of this work will be much longer than with other methods of precession determination.

Wright stressed that the polar method had an advantage over others as it gave fully independent determination of precession.

The pavillion of the photographic tube is sealed so that during the night the temperature inside is nearly constant and causes no deformation of the instrument. The observation process is fully automatic. Investigations of the stability of the Pulkovo PT's foundations with a very sensitive Ostrovsky tiltmeter were conducted (Bakhrakh *et al.*, 1986). The results showed that the change in inclination amplitude did not exceed $0\farcs03$.

In astrophotographic observations special methods are used, both of laboratory type and based on observations of reference stars, to decrease the systematic errors. For the PT examination first the special Zeiss optical tube was used, with which the optic axis position in the focal plane was determined. Later, according to Naumov's project a new optical tube was constructed at Pulkovo Observatory, with which the optic axis position in the focal plane could be determined as an angle between a line perpendicular to the photoplate plane or as an optic axis.

A. A. Mikhailov estimated the probable precision of the precession constant evaluation based on observations with the PT (Mikhailov, 1949). He proposed that the polar motion might be attained with an error of $\pm 0\farcs006$ from 19-years observation series. This might give an error of $\pm 0\farcs0008$ for the precession constant, but errors of the proper motions of observed stars and the plate scale errors would reduce the precision of the result. In this case the precession constant might be derived with an accuracy of $\pm 0\farcs005$.

A rms error of PT plate scale does not exceed $\pm 0\farcs00025$ at present and cannot influence the precision of the precession constant calculation.

Thus, the accuracy of the absolute proper motions of the observed stars and the duration of observation series remain the main source of errors in the precession constant calculation based on observation series with PT. If the error of the proper motions of all PT stars does not exceed $0''.01$ during 40 years of observation, the accuracy of the determined precession constant could be on the present-day level (Naumov, 1989).

In 1993 the catalog NPM1 was published (Klemola, 1993). It is a resulting Catalog of the Lick Northern Proper Motion (NPM) program. The NPM1 Catalog provides absolute proper motions, positions, etc. for some 149 000 stars north of declination −23°. The rms errors of the NPM absolute proper motions are of about $0''.5$/century. The catalog contains 6 of 30 stars observed with the PT during the period of 1957–1993: +89.0024, +89.0003, +89.0019, +89.0026, +89.0020, +89.0014. Though it is hard to tell about the proper motions accuracy for this small selection, we have used the NPM1 catalog data to calculate the precession based on our observation series. The observed data reduction method, we used, gives instant polar distances of stars. Thus, we obtain the correction to the precession in declination.

The value of the correction we derived based on 1957–1993 series is $-0''.002 \pm 0''.025$/year. To investigate the reasons of the big error we calculated the values of the correction to precession in declination based on each star observation data separately. The rms errors have small differences from the whole result error, except that for star No +89.0020 which gives a large value of rms error as it is faint and thus was observed rarely. After its elimination from the whole procession we received the result given above.

Therefore, the value of rms error of correction to the precession in declination we obtained may have been caused by large errors of the proper motions as well as by the low number of stars used in calculations. With the precise absolute proper motions for the rest of stars observed with PT, we might calculate the result to within $0''.01$ as we had supposed above. Evidently, the absolute proper motions of other 24 stars observed in the polar zone are needed to achieve better accuracy.

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