ON THE PRECISION OF STAR POSITIONS OBSERVATION MADE WITH THE PULKOVO HMC.

T.KIRIAN
Central Astronomical Observatory (Pulkovo)
196140 St-Petersburg, Russia
G.PINIGIN
NIkolaev Astronomical Observatory
327030 Nikolaev, Ukraine

ABSTRACT. After the automation of the Pulkovo HMC two catalogs of Positions of 1081 Stars from FK5B, FK4S, FKFS and RRS were observed. Every star was observed more than three times during the period from March 1988 to May 1990. The internal error of a single observation of FK5 stars was estimated as $0\overset{s}{.}015(\mathrm{Sec}\cdot Z)^{0.6}$, $0\overset{''}{.}16(\mathrm{Sec}\cdot Z)^{0.9}$ in α and δ. A comparison of the declination of FK5B Stars observed with HMC with those of Bordeaux 86, CAMC 86 and PMC 86÷88 shows the $\Delta\delta_{\delta}$ differences of the order of $0\overset{''}{.}1$ in the declination zone $40^{\circ}\div60^{\circ}$.

1. INTRODUCTION.

After the automation of the Pulkovo HMC in 1986 two differential catalogues the right ascensions and declinations Pu(HMC)88 and Pu(HMC)89,respectively were observed during the period from March 1988 to May 1990 (Gumerov et al. 1986, Kirian et al. 1992). The Pu(HMC)89 catalogue consists of 170 AGK3 reference stars near 63 Radio sources. The Pu(HMC)88 catalogue consists of 911 selected stars from FK5B, FK4S and FKFS, 502 of these belong to the FK5. Every star was observed more than three times over 80 nights. The star observations and measurements of the instrumental constants (the mirror tilt and relative azimuth of the mirror, zero-point and division errors of the devided circle and the tube inclination) were carried out with the HMC computer control. The collimation of the mirror was determined using star observations. The star list program for the HMC enables observations without vignetting of the objective with the mirror rims. The irregularities of the form of the reflecting mirror surface were not more than 0.1λ.

2. REDUCTION PROCESS.

The procedure of the reduction of the right ascention and declination observations was fully described by Kirian et al. (1992). The basic expressions for the case of S tube are given by

$$(O - C)_{\alpha} = (u + m) + n\cdot tg(\delta) + 2\cdot c\cdot Cos(45^{\circ} - \frac{\varphi-\delta}{2})\cdot Sec(\delta) + \Delta\mu_{S}[Sin(\varphi - \delta) + 1]\cdot Sec(\delta) + (u + m)'\cdot\Delta t + n'\cdot tg(\delta)\cdot\Delta t + 2\cdot c'\cdot Cos(45^{\circ} - \frac{\varphi-\delta}{2})\cdot Sec(\delta)\cdot\Delta t \quad (1)$$

$$(O - C)_{\delta} = (\Delta\varphi_{\circ} + \Delta M'_{\circ}) + b\cdot Sin(2\cdot Z) + \Delta r\cdot tg(Z) \quad (2)$$

where (u+m),n and (u+m)' ,n' are the Besselian constants and their rates of change; c and c' are the collimation and its rate of change; $\Delta\mu_S$ is the correction to the relative azimuth of the mirror; $\Delta\varphi_{\circ}$ and $\Delta M'_{\circ}$ are

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the corrections to the adopted latitude and zero-point of the devided circle (including the tube inclination); b is the horizontal flexure of the mirror; Δr is the refraction correction and Z is the zenith distance. Seven constants (u+m), n, (u+m)', n', c, c', $\Delta\mu_s$ in case of α and three constants ($\Delta\varphi_o+\Delta M'_o$), b, Δr in case of δ were determined for each night by the least squares solution for all the FK5B stars observed. Before forming the means of all observations and giving the final catalogue positions, the individual observations which were not completely within a 3σ limit were rejected. Some nights with a small number of reference stars especially for the right ascension catalogs were excluded too.

3. ACCURACY.

3.1. ACCIDENTAL ERRORS.

Estimates of the mean error of a single observation are based on a comparison of the individual observations of the same star observed during the observational period. The table shows the data on the accuracy of the HMC observations for different star groups.

Table. Mean error of a single HMC observation during 1988-90.

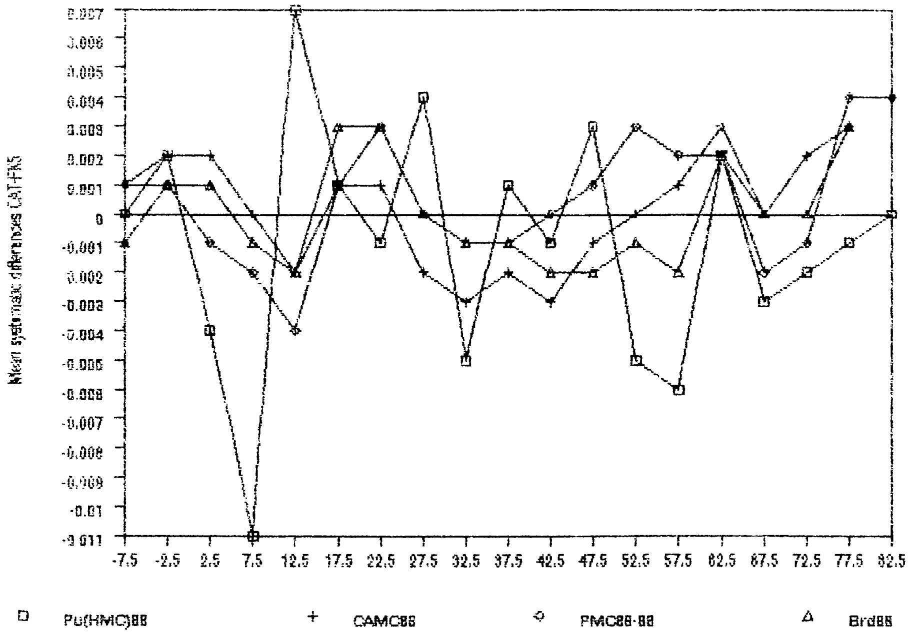
Star group	$\varepsilon_\alpha \cdot \mathrm{Cos}(\delta)$	ε_δ	n
FK5B	$\pm0\overset{s}{.}015(\mathrm{SecZ})^{0.6}$	$\pm0\overset{''}{.}16(\mathrm{SecZ})^{0.9}$	4.1
FK5B+FK4S+FKFS	$\pm0\overset{s}{.}017(\mathrm{SecZ})^{0.6}$	$\pm0\overset{''}{.}17(\mathrm{SecZ})^{0.9}$	3.3
AGK3(FRS-LAZ)	$\pm0\overset{s}{.}024$	$\pm0\overset{''}{.}20$ SecZ	3.1

where n is the average number of observations for single star.

The accuracy of the HMC observations is nearly the same as that of the CAMC observations and of the PMC observations (Morrison et al. (1990), Yoshizawa et al. (1989), Yoshizawa et al. (1992)). The HMC accuracy of declination determination is high, but that of the right ascension determination is somewhat lower. This is due to the fact that the connection of the right ascention system of two HMC tubes was not fully correct, because the collimation was determined using star observations. Also the HMC accuracy for faint stars was somewhat lower because the scanning time for all stars was constant and equal to 40 seconds. It is to be noted that the scanning time for faint stars by CAMC and PMC was larger and equals to about two minutes.

3.2. SYSTEMATIC ERRORS.

The Positions of the FK5B stars in the Pu(HMC)88 catalogue were compared with their positions in the FK5 catalogue for the purpose of studying systematic differences between the two catalogues. The Fig. shows the variation of $\Delta\alpha_\delta \cdot \mathrm{Cos}(\delta)$ and $\Delta\delta_\delta$ for the Pu(HMC)88 at the mean epoch for the FK5B stars for every declination zone in steps of 5°. The HMC system shows a sufficient stability with time and temperature during two years. The mean errors of the HMC systematic differences are



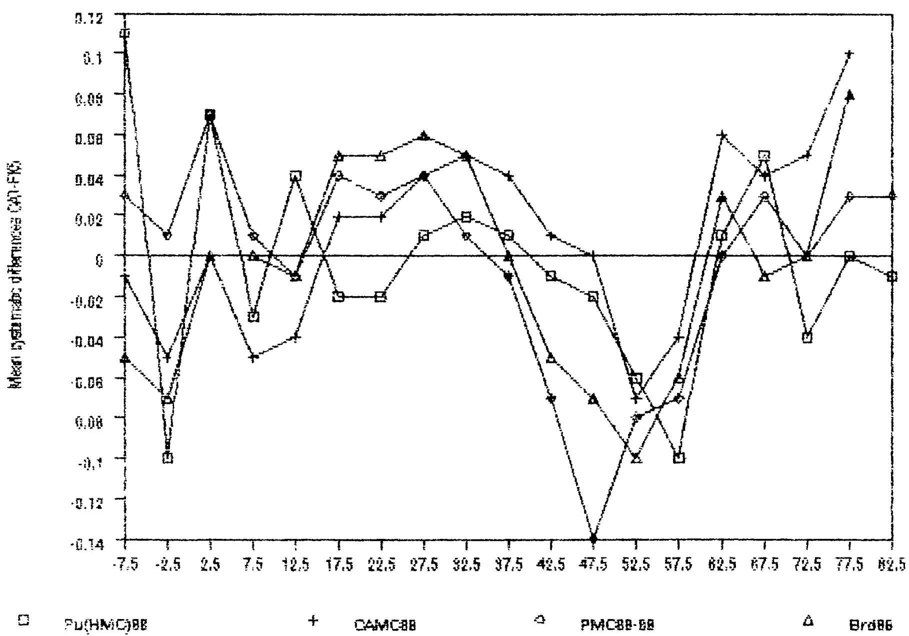


Fig. The comparison of the mean systematic differences $\Delta\alpha_{\delta}\mathrm{Cos}\delta$ and $\Delta\delta_{\delta}$ in the sense of Cat-FK5, found in Pu(HMC)88, Brd86, CAMC86 and PMC86-88.

$\pm 0^s\!.002 \div 0^s\!.003$ in right ascension and $\pm 0''\!.02 \div 0''\!.03$ in declination. For the comparison this accuracy is the same as for PMC86, but for the HMC fewer number of observations were used (Yoshizawa et al. (1989)). It shows a better efficiency of the HMC. The mean variations of the HMC systematic differences is not very large - not more than $0^s\!.005$ in $\Delta\alpha_\delta \cos\delta$ and not more than $0''\!.10$ in $\Delta\delta_\delta$.

In this Fig. are visualized also the comparisons with the differences of considered catalogues with respect to the FK5 system among the Tokyo PMC86÷88 (Yoshizawa et al. 1992), CAMC86 (Morrison et al.1990), and Bordeaux86 (Morrison,Argyle et al. 1990). All four catalogues show similar coincidence and good agreement of the mean variations with the accuracy of the mean error level of about $0''\!.02$ or 0.03 (Yoshizawa et al.1989). We believe that the systematic accuracy for Pulkovo HMC is the same. This enabled us to reach a conclusion about a very insignificant influence of instrumental parameters, some of which were very small (pivot and flexure errors) and some very stable and determinable (division and collimation errors).

The results of independent observations obtained with four different instruments reveal systematic errors in the FK5 reaching $0''\!.05 \div 0''\!.1$ in some regions of the sky. The FK5 system shows systematic $\Delta\delta_\delta$ errors of about $0''\!.1$ in the declination zone $40^\circ < \delta < 60^\circ$. That systematic error has been found with HMC observations in 1982-83 (Aupov et al. (1991)). The systematic $\Delta\alpha_\delta \cdot \cos(\delta)$ error is smaller and seems to reach about $0''\!.03$ in the declination zone $0^\circ < \delta < 25^\circ$.

4. CONCLUSION

1) The Pulkovo automatic HMC shows high stability and accuracy about $0''\!.02 \div 0''\!.03$. This permits to investigate systematic errors of the FK5 system.

2) The Pulkovo HMC catalogues observed during 1988-90 can be used for improvement of stellar positions of FK5 stars and for obtaining a link between optical stellar frame and extragalactic primary reference frame.

REFERENCES

Aupov, F.G., Gumerov, R.J., Kapkov, V.B., Bagildinsky, B.K., Ersov, V.N., Naumov, K.N., Nikiforova, O.Yu., Kirian, T.R., Ostrensky, Yu.G., Streletsky, Yu.S., Smirnov, B.N., Pozhalov, A.A., Shkutov, V.D., Pinigin, G.I., Sergeev, A.V., Shornikov, O.E. (1991) 'A new generation of Pulkovo observatory meridian instruments and the first results of observations', Astrophysics and Space Science 177, pp.219-223.

Fifth Fundamental Catalogue (1988) Veroff. Astron. Rechen-Inst., Heidelberg, No.32.

Gumerov,R., Kapkov,V. and Pinigin,G. (1986) 'Automatic horizontal meridian circle at Pulkovo', in H.Eichhorn and R.J.Leacock (eds.), Astrometric Techniques, Kluwer Acad. Publ., Dordrecht, pp.459-462.

Morrison,L.V., Argule,R.W., Helmer,L., Fabricius,C., Einicke,O.H. Quijano,L. and Muiños,J.L. (1990) 'Optical reference frame defined by Carlsberg meridian Catalogue La Palma Number 4', in J.H.Lieske and V.K.Abalakin (eds.), Inertial Coordinate System on the Sky, Kluwer Acad. Publ., Dordrecht, pp.391-401.

Morrison,L.V., Argule,R.V., Requieme,Y., Helmer,L., Fabricius,C., Einicke,O.H., Buontempo,M.E., Muiños,J.L. and Rapaport,M. (1990) 'Comparison of FK5 with Bordeaux and Carlsberg meridian circle observations',Astronomy and Astrophysics 240, pp.173-177.

Kirian,T.R., Naumov,K.N., Smirnov,B.N., Nikiforova,O.Y., Gorshanov,D.L, Pinigin,G.I., Protsyuk,Y.I., Kapkov,V.B., Gumerov,R.I. and Aupov,F.G. (1992) ´The Results of the differential determination of the right ascention and declination of the stars made by Pulkovo Sukharev´s HMC at 1988-90´, VINITI 6.05.92, N.1488-B92 (in Russian).

Yoshizawa M. and Suzuki S. (1989) ´The Tokyo PMC Catalog 86: Catalog of position of 3974 Stars observed in 1986 with Tokyo photoelectric meridian circle´, Publ. Nat. Astron. Obs. Japan 1, pp.127-176.

Yoshizawa,M., Suzuki,Sh. and Sôma,M. (1992) ´The Tokyo PMC Catalog 88: Catalog of Positions of 3800 Stars observed in 1988 and planetary positions observed in 1986 to 1988 with Tokyo photoelectric meridian circle´, Publ.Nat.Astron.Obs. Japan 2, pp.475-546.