Revista Mexicana de Astronomía y Astrofísica, **33**, 3–8 (1997)

COMPARISON OF THE ACRS AND PPM CATALOGS WITH THE FK5 IN THE SOUTHERN HEMISPHERE

S.P. Puliaev [1,2], C.A. Moraes de Siqueira [1,3], A.H. Andrei [1], G.G. Vieira [3], and L. Cichetto [1,3]

Received 1996 June 19; accepted 1996 September 28

RESUMEN

Presentamos la comparación del Astrographical Catalog of Reference Stars (ACRS) y el catálogo Positions and Proper Motions (PPM) con el FK5 en el hemisferio sur. Las posiciones de las estrellas del FK5, distribuidas uniformemente en la esfera celeste, fueron determinadas usando métodos de astrofotografía. Estas posiciones fueron reducidas en los sistemas de ACRS y PPM para la época de las observaciones y comparadas después con las posiciones del FK5. Aquí se presentan las diferencias sistemáticas (FK5 – ACRS) y (FK5 – PPM) así obtenidas para declinaciones entre −30° y el Polo Sur para la época 1994.50 .

ABSTRACT

A comparison of the Astrographical Catalog of Reference Stars (ACRS) and the Positions and Proper Motions Catalog (PPM) with the FK5 in the southern hemisphere, is presented. To this aim, the positions of FK5 stars uniformly spread over the celestial sphere were astrographically taken. These positions were reduced in the ACRS and PPM systems and then compared with those from the FK5 for the epoch of observation. The (FK5 – ACRS) and (FK5 – PPM) systematic differences thus obtained, in the declination range from −30° down to the South Pole, for the mean epoch of 1994.50, are shown.

Key words: **CATALOGS — REFERENCE SYSTEMS**

1. INTRODUCTION

Formally, all the recent reference catalogs were observed or, for the compiled catalogs, were calculated in the FK4 or FK5 system. Yet some systematic errors of different origins remain, relatively to the fundamental system. The component catalogs for both the Astrographical Catalog of Reference Stars 'ACRS' (Corbin & Urban 1991) and the Positions and Proper Motions Catalog 'PPM' (Röeser & Bastian 1993) were based on the catalog of International Reference Stars (Corbin 1991), which was compiled on the FK4 system and then converted to the FK5. The direct comparison of either the ACRS or the PPM with the FK5 does not present reliable results because of the small number of common stars.

At the same time, these catalogs are unique as the present dense reference systems of choice employed for investigations in the areas of astrometry and celestial mechanics. Furthermore, modern astrometric observations can be carried out with CCD detectors, which have small fields, generally of a few arcminutes. So, CCD observations, for instance, of minor planets and natural satellites of the planets are reduced using positions of reference stars from the Guide Star Catalog 'GSC' (Lasker et al. 1990), updated to the PPM system (Röeser 1995). The systems of the ACRS and PPM are employed in more dense catalogs (López García & Yagudin 1995), and their quality in a systematic sense must be known. This refers especially to the southern hemisphere, since, as it is well known, the reference catalogs in the south are worse both in the systematic and accidental senses than in the north.

In 1994 we observed a program of FK5 (Part I) stars from the South Pole to −30° of declination with the Zeiss-Jena astrograph (F = 2 m, D = 40 cm) of the Universidade Federal do Rio de Janeiro at the Observatory of Campinas, São Paulo (−23° latitude). The plate type used was Kodak IIa-O, 16 ×

[1] Observatório Nacional/CNPq, Brazil.
[2] Pulkovo Observatory, Russia.
[3] Observatório do Valongo/UFRJ, Brazil.

16 cm, and the field size 3° × 3°. The measurements of the plates have been made with the automated microdensitometer PDS 1010A of the Observatório Nacional with an internal positional precision of one micron or 0.″1.

2. OBSERVATIONS AND REDUCTIONS

The goal of this work is to determine systematic differences of the reference catalogs ACRS and PPM relative to the FK5. The positions of the FK5 (main catalog) stars on our photographic plates were reduced in the systems of the ACRS and PPM, that is, the reference stars were taken from these catalogs. These positions were then compared with those from the FK5, transferred to the epoch of our photographic observations, using FK5 proper motions. Thus the comparison between the FK5 (Fricke et al. 1988) star positions and their positions in the ACRS and PPM system gives the systematical differences between the ACRS and PPM, and the fundamental system.

A total of 59 plates was measured with the microdensitometer PDS 1010A of the Observatório Nacional, and then reduced. Here we report the results obtained; i.e., the systematic errors $\Delta\alpha\cos\delta$ and $\Delta\delta$ of the ACRS and PPM catalogs as function of right ascension and declination in the zone of declination from −30° to the South Pole.

The distribution of the chosen FK5 stars places one star per area of 2 hours of right ascension, and 10° of declination. For minimizing a possible magnitude equation, the faintest FK5 stars were taken in order to be closer to the mean magnitude of the stars from the reference catalogs. Consequently, the mean magnitude of the observed FK5 stars is $5.^m5$. Since the measured region on the plates was 9 square degrees, there was only one FK5 star per plate. All the observations were made in 1994 and their mean epoch is 1994.50

Two exposures with 1^m 30^s and 40^s of each FK5 star in the center of the field were made, thus producing two sets of images on every plate. The plates were measured in the direct and inverse directions. Four sets of independent measurements were therefore obtained per plate: two directions of the scan and two sets of images. Three consecutive scans were made for the FK5 star images, so the reduction of every plate produced twelve positions of the stars in the systems of the ACRS and PPM catalogs. The measured rectangular coordinates of the image centers were determined through two dimension elliptical Gaussian fits, with the r.m.s. adjustment error smaller than 0.″05. To relate the measured and standard coordinates of the reference stars, we calculated 12 plate constants using a 2nd degree polynomial model with a 3rd degree radial distortion term as the best mathematical model in our case (Vieira, Assafin, & Vieira Martins 1992). The reductions wei using an average of 40 reference ACRS stars PPM stars per plate. The mean internal e reductions, determined from the internal con of the reduction process, are:

$\sigma_\alpha\cos\delta = 0.''20, \quad \sigma_\delta = 0.''20$ for the PPI

$\sigma_\alpha\cos\delta = 0.''22, \quad \sigma_\delta = 0''.22$ for the AC

The final position of each FK5 star in tl and ACRS systems is the arithmetic mear twelve reduced positions. Hereafter, we deno as PPM and ACRS respectively. The catal tions from the FK5 were transformed to the e observations using the FK5 proper motions, a the differences $\Delta\alpha\cos\delta$ and $\Delta\delta$ in the sense PPM) and (FK5 − ACRS) were calculated.

The HIPPARCOS stars in each plate h their rectangular coordinates measured. Thu the HIPPARCOS catalog becomes available, orientation relative to the extragalactic rad ence frame is known, the steps similar to tl lowed here will likewise give the orientatio southern ACRS and PPM systems relative tc tragalactic frame at the mean plate epoch.

3. RESULTS

We report here the results obtained from 5 in the southern zone, whose centers are betwe and −90°. The main results are displayed in which presents the individual differences betv position of each star updated from the FK5 position obtained in the ACRS and PPM s Figure 1 represents the data from Table 1 in mode. Filled circles refer to the (FK5 − AC open circles to the (FK5 − PPM) individual nate differences.

The systematic differences $\Delta\alpha_\alpha\cos\delta$ are in Fig. 1*(a)*, for both the cases: (FK5 − and (FK5 − PPM). Analogously, the system ferences $\Delta\delta_\alpha$ are shown in Fig. 1*(c)*. The also present smoothed curves binning the diff through four points running averages, enabli sualize large trends and to compare the AC PPM features. Solid lines refer to the AC dotted lines to PPM. The amplitudes of the atic differences reach the level of 0.″2 for th and 0.″3 − 0.″4 for the PPM. Naturally, the atic differences between the FK5 and the AC PPM in the greatest part are due to the sys errors of the last two. Actually, the FK5 h systematic errors too, as indicated by differer tigations and new meridian observations, b do not exceed 0.″1 (Morrison et al. 1991), a urally, the ACRS and the PPM are defined as ing the FK5 system.

In the figures, the curve $\Delta\alpha_\alpha\cos\delta$ (FK5 − lies higher than the $\Delta\alpha_\alpha\cos\delta$ (FK5–PPM). dicates that the right ascensions in the PPM

TABLE 1

DIFFERENCES BETWEEN THE FK5 POSITIONS OF STARS AND THEIR POSITIONS OBTAINED IN THE ACRS AND PPM SYSTEMS[a]

			(FK5 – ACRS)		(FK5 – PPM)	
FK5	R.A.	Decl.	$\Delta\alpha\cos\delta$	$\Delta\delta$	$\Delta\alpha\cos\delta$	$\Delta\delta$
1017	0.75	– 42.7	170	3	– 44	– 144
0031	0.81	– 74.9	– 8	27	– 257	95
1027	1.03	– 57.0	– 188	– 90	– 407	– 90
0044	1.21	– 37.9	– 157	– 122	– 166	– 77
1038	1.42	– 64.4	78	– 59	– 133	– 143
1076	2.68	– 54.5	– 44	211	110	– 40
1086	3.05	– 47.0	– 85	104	10	53
1090	3.24	– 35.6	– 385	– 198	– 437	– 218
1095	3.27	– 77.4	– 421	189	– 251	499
0141	3.74	– 64.8	– 30	– 104	– 50	39
0163	4.36	– 63.4	– 104	284	– 161	372
1138	4.92	– 74.9	43	211	– 79	50
0917	4.98	– 82.5	230	372	30	308
1143	5.12	– 44.8	84	– 284	– 69	– 24
0239	6.17	– 74.8	143	125	– 242	83
1178	6.79	– 37.9	– 75	447	– 506	339
0272	7.07	– 56.7	62	– 150	– 18	– 279
1184	7.07	– 42.3	88	338	– 77	309
0281	7.28	– 68.0	380	166	123	74
0918	8.94	– 85.7	85	204	141	352
0343	9.04	– 66.4	– 93	134	– 101	134
0345	9.13	– 43.4	208	331	130	368
0353	9.37	– 55.0	– 28	– 211	15	– 148
0362	9.53	– 73.1	129	79	– 160	0
0406	10.72	– 64.4	39	– 219	8	– 438
1664	10.99	– 84.6	138	285	– 245	531
1290	11.20	– 32.4	– 169	109	– 190	169
1294	11.41	– 42.7	– 113	180	– 373	365
0438	11.62	– 75.9	– 57	– 134	– 499	222
1331	12.84	– 34.0	51	– 23	14	– 158
0919	12.92	– 85.1	– 273	562	– 227	549
1340	13.13	– 53.5	121	– 141	– 8	40
1343	13.29	– 44.0	198	– 114	48	– 109
0503	13.65	– 75.7	– 67	– 313	– 303	– 361
0530	14.42	– 68.2	239	9	– 65	– 236
0546	14.78	– 52.4	94	118	130	147
1389	14.93	– 33.9	452	– 140	358	056
0567	15.53	– 73.4	94	– 115	– 140	176
0631	16.98	– 56.0	– 202	109	– 390	70
1443	17.02	– 76.2	243	65	– 199	– 18
0921	17.02	– 86.4	134	405	– 27	79
0638	17.20	– 43.2	125	129	55	164
0661	17.76	– 64.7	181	83	207	264
1490	18.81	– 43.7	– 165	– 138	– 300	– 101
0704	18.87	– 62.2	– 180	– 6	– 188	– 142
0922	18.91	– 87.6	– 128	80	– 202	48
1499	19.27	– 75.8	64	– 70	– 377	– 165
1501	19.33	– 35.4	257	68	63	59

TABLE 1 (CONTINUED)

FK5	R.A.	Decl.	(FK5 – ACRS) $\Delta\alpha\cos\delta$	(FK5 – ACRS) $\Delta\delta$	(FK5 – PPM) $\Delta\alpha\cos\delta$	(FK5 – PPM) $\Delta\delta$
1504	19.46 –	54.3	– 194	410	– 98	156
1540	20.67 –	33.4	– 97	– 28	– 394	19
0775	20.75 –	66.2	286	132	208	116
0787	21.08 –	77.0	35	231	36	256
0796	21.26 –	53.3	– 73	– 195	– 248	– 106
1670	22.53 –	86.0	416	355	200	261
0865	22.91 –	70.1	– 353	59	– 386	– 27
1601	23.06 –	34.7	– 150	115	– 123	– 7
1605	23.17 –	45.2	– 75	87	– 39	– 162
0876	23.28 –	62.0	– 303	– 58	– 416	33
0883	23.44 –	52.7	237	172	4	36

[a]. In miliarcsec.

are systematically larger than the right ascensions in ACRS in this zone of declinations. It follows that the PPM zero point of right ascension is displaced to the west relative to that of the ACRS by 0.″13 or 0.^{s}009. The same difference in zero points of right ascension in Evdokimov et al. (1995) is 0.″07 and 0.″05 in Assafin et al. (1996). The direct comparison between the two catalogs, in the declination zone from −30° to −90°, was performed including 60 990 common stars and revealed a systematic right ascension difference of 0.″127, confirming the offset indicated by the observations. The difference between solid and dotted lines on Fig. 1*(a)* must represent the systematic differences (ACRS – PPM) in our zone. We compared the obtained (ACRS – PPM) with those calculated directly in Evdokimov et al. (1995) for all stars common to both catalogs in the −70° to −90° declination range and found a good concordance. This shows the reality of the (FK5 – ACRS) and (FK5 – PPM) systematic differences obtained here.

As for the $\Delta\delta_\alpha$ differences between the FK5 and the reference catalogs, they have the same level of amplitude as $\Delta\alpha_\alpha\cos\delta$ differences, but they are slightly larger in scatter. This can be explained by the existence of the considerable $\Delta\delta_\delta$ systematic errors. This is the probable cause of the oscillation of the fitted curves.

Fig. 1*(b)* and *(d)* show the systematic differences $\Delta\alpha_\delta\cos\delta$ and $\Delta\delta_\delta$. The amplitudes of the smoothed curves are of the same order as those in *(a)* and *(c)* for the dependences on right ascension. The dominating feature refers to the declination systematic errors of the ACRS and the PPM near the South Pole, which reaches 0.″4.

The systematic differences between the FK5 and the catalogs ACRS and PPM clearly exhibit common features. This is explained since both of them were compiled mostly from the same common base catalogs, as the Second Cape Photographic Catalog 'CPC2' (de Vegt et al. 1989) and the Yale photographic zones (Yale Transactions, Vols. 11-32). The main differences between the ACRS and the PPM in the southern hemisphere are that the ACRS employs more catalogs, especially meridian circle ones, and the PPM includes FOKAT, whereas ACRS does not.

4. CONCLUSIONS

The results obtained show the existence of systematic errors in the catalogs ACRS and PPM in the southern hemisphere for the epoch 1994.50, with maximum amplitudes of 0.″2 to 0.″4. The errors of the PPM are found to be larger than those of ACRS.

The zero point of right ascension of the PPM was found displaced 0.″13 to the west relatively to that of the ACRS. The ACRS is found nearly coincident with the FK5 right ascension zero point, the displacement being 0.″02 ± 0.″02, to the east. As for the PPM, the found displacement is 0.″11 ± 0.″02, to the west. This result confirms the findings of previous investigations.

Many of the features displayed by the fitting curves must be taken with caution, and the $\Delta\delta_\alpha$ fit in this sense is typical. They may represent small-scale fluctuations or simply are due to the precision of positions in the ACRS and in the PPM. However, it is equally possible that they result from the discrete number of stars used at each declination, and the FK5 stars individual position and proper motion errors can amount to 0.″2 for some stars at 1995. Nonetheless, there are features that stand above the

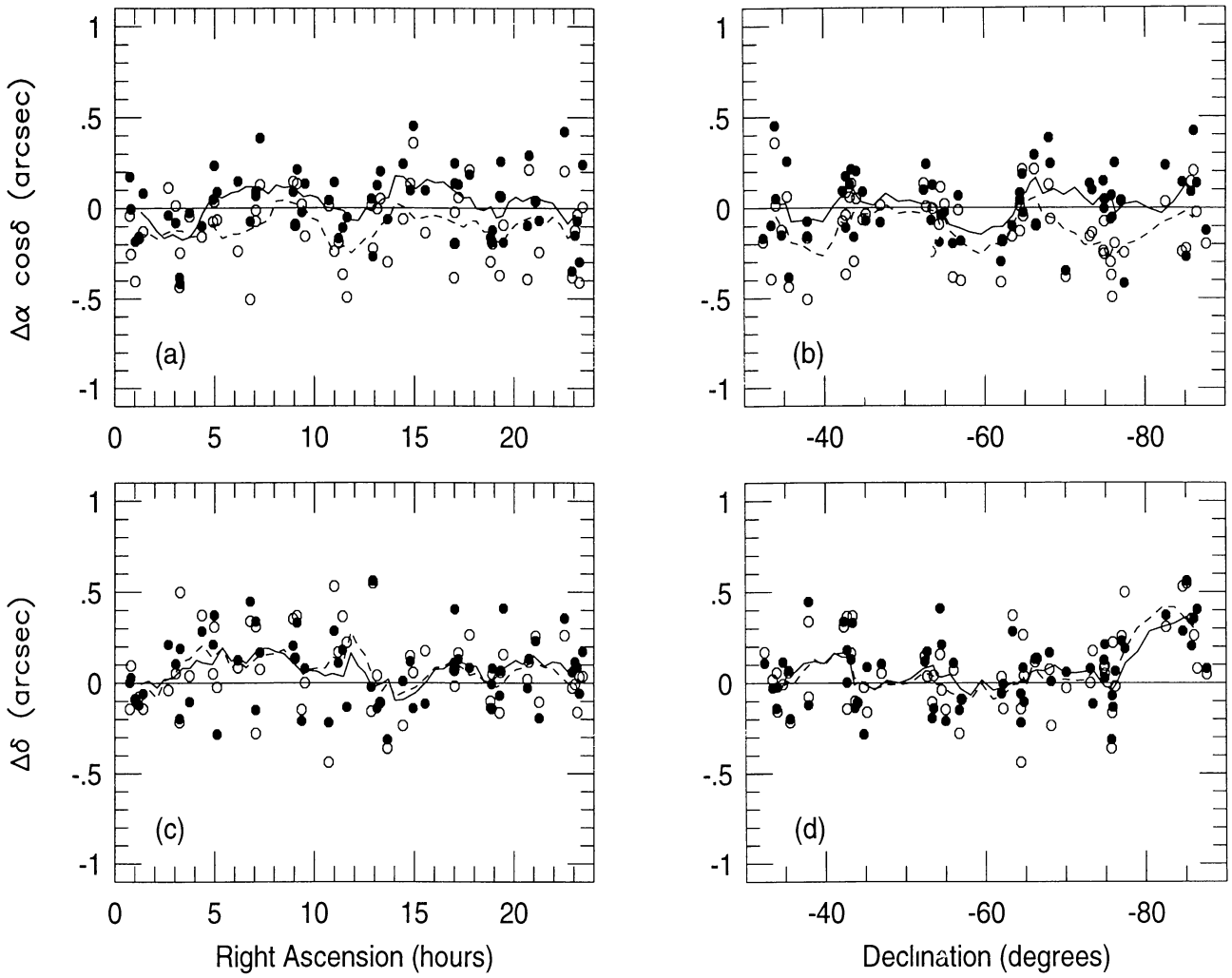

Fig. 1. Systematic differences (FK5 – ACRS) and (FK5 – PPM), in right ascension ($\Delta\alpha\cos\delta$) and declination ($\Delta\delta$), plotted against right ascension and declination. The (FK5 – ACRS) differences are represented by the filled circles and fitted by the continuous lines. The (FK5 – PPM) differences are represented by the open circles and fitted by the dotted lines.

noise level, like the positive trend in the $\Delta\alpha_\alpha\cos\delta$ plot between 5^h and 10^h, and in the $\Delta\alpha_\alpha\cos\delta$ plot close to the polar cap. The most important feature, representing the largest error for both catalogs is found in the $\Delta\delta_\delta$ plot, in the declination range $-80°$ to $-90°$, where the warps exceed $0.''4$.

We acknowledge Las Campanas Observatory for the donation of the plates used in this work. Reductions of the plates were made using the FORTRAN programs written by M. Assafin. We thank M.A. Nunes for his assistance on the PDS operation. We thank the anonymous referee for the most useful comments. SP thanks the CNPq (Brazil) for the financial support under the contract 300017/93-6(RN).

REFERENCES

Assafin, M., Andrei, A.H., Puliaev, S., Jilinski, E.G., Vieira-Martins, R., Vieira, G.G., & de Oliveira, W.M. 1996, A&AS, 117, 335

Corbin, T.E. 1991, International Reference Stars Catalog; (Washington: U.S. Naval Observatory)

Corbin, T.E., & Urban, S.E. 1991, Astrographic Catalog Reference Stars (Washington: U.S. Naval Observatory)

de Vegt, Ch., Zacharias, N., Murray, C.A., & Penston, M.J. 1989, in Star Catalogs: A Centennial Tribute to A.N. Vyssotsky (Schenectady: L. Davis Press), 45

Evdokimov, A.E., Pikin, Yu.D., & Potter H.I. 1995, Preprint No.1, Pulkovo Observatory, ISBN 5-85381-063-4

Fricke, W. et al., 1988, Veröff. Astron. Rechen-Inst., Heidelberg, No. 32

Lasker, B.M., Sturch, C.R., McLean, B.J., Russel J.L., Jenkner, H., & Shara, M.M. 1990, AJ, 99, 6, 2019

López García, A., & Yagudin, L.I. 1995, in IAU Symp. 172, Dynamics, Ephemerides and Astrometry of the Solar System, ed. S. Ferraz-Mello, B. Morando, & J.-E. Arlot (Dordrecht: Kluwer), 483

Morrison, L.V., Gibbs, P., Helmer, L., Fabricius, C., Einicke, O.H., Réquième, Y., & Rapaport, M. 1991, Ap&SS, 177, 31

Röeser, S., & Bastian, U. 1993, Bull. Inf. CDS 42, 11

Röeser, S. 1995, in IAU Symp. 172, Dynamics, Ephemerides and Astrometry of the Solar System, ed. S. Ferraz-Mello, B. Morando, & J.-E. Arlot (Dordrecht: Kluwer), 481

Vieira, G.G., Assafin, M., & Vieira Martins, R. 1992, PASP, 104, 467

Yale Transactions. 1939-1972, Vols. 11-32 (New Haven: Yale Observatory)

A.H. Andrei and Serguei P. Puliaev: Observatório Nacional/CNPq, rua Gral. José Cristino 77, CEP 20921-400 São Cristovão, Rio de Janeiro, Brazil. (puliaev@dans.on.br).

L. Cichetto, C.A. Moraes de Siqueira, and G.G. Vieira: Observatório do Valongo/UFRJ, Ladeira Pedro Antonio 43, CEP 20080, Rio de Janeiro, RJ, Brazil.