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Third San Juan photoelectric astrolabe catalogue (CPASJ3)⋆

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Abstract. Resulting from the cooperation between Beijing, San Juan and La Plata Astronomical Observatories, the photoelectric astrolabe Mark II(PAII) of the Beijing Astronomical Observatory was moved and installed at the San Juan Observatory, Argentina in January, 1992 for observations of stars in the southern hemisphere. Using the data observed with the instrument from Feb. 23 1992 to Mar. 11, 2000 over 2382 days, the Third San Juan photoelectric astrolabe catalogue has been compiled from double transits at both the eastern and western passages. There are 6762 stars in this catalogue, including 6156 Hipparcos stars (in which there are 69 radio stars), 8 FK5 stars, 47 SRS stars, 551 CAMC4 stars. The mean precisions are ±3.0 ms and ±0.053″ in right ascension and declination, respectively. The magnitudes of stars are from 1.0 to 11.5. The declinations are from −3° to −60°. The mean epoch is 1996.3. Systematic corrections of (CPASJ3−Hipp) are given.

Key words. catalogs – astrometry – reference systems

1. Introduction

The photoelectric astrolabe Mark II No. 2 were built at the Nanjing Astronomical Instrument Factory in 1974. The instrument was installed at the Shahe Station of the Beijing Astronomical Observatory at the end of 1975 and has been in operation since Mar. 1976 (Luo 1979). The aperture of the primary mirror is 200 mm and that of the secondary mirror 49 mm. The equivalent focal length is 2400 mm. The zenith distance of observation is 30°. A vacuum telescope tube and two reflecting mirrors with a stable angle are used. This optical system of the astrolabe is quite stable.

Since 1980, several general catalogues of stars (Zhu et al. 1981; Working Group of GCPA 1983; Working Group of CGSC 1991; Lu 1991) have been compiled using the data observed with the different types of Chinese photoelectric astrolabes.

The Fundamental Reference System of Stars project is important for astrometry. Although Hipparcos has made remarkable achievements, there are also many things remaining after Hipparcos (Clauzet et al. 1990; Kovalevsky 1991), such as: the improvement of fundamental reference system of stars; the extension of the fundamental catalogue to faint stars; the maintenance of the Hipparcos reference system; the extension of the Hipparcos catalogue. Two types of ground-based instruments can fulfil these roles: the photoelectric meridian circles and the photoelectric astrolabes, which both give star positions with a r.m.s. precision of the order of 0.1″.

Resulting from the cooperation between Beijing, San Juan, and La Plata Astronomical Observatories, the photoelectric astrolabe Mark II No. 2 of the Beijing Astronomical Observatory was moved and installed at the San Juan Observatory, Argentina in January, 1992 for observations of stars in the southern hemisphere.

Using the data observed in San Juan with the instrument, several catalogues of stars (Lu et al. 1996; Manrique et al. 1999) were published. In this paper, we present all results obtained during the cooperation from Feb. 1992 to Mar. 2000.

2. Reduction of the data

The list of stars is selected from the Hipparcos Catalogue and the FK5 Fundamental Catalogue provided by the CDS, CAMC4 and SRS catalogues. Radio stars are taken from the literature(Walter 1990). All the positions of stars have been reduced to the epoch and equinox J2000.0.

⋆ The catalogue is only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/430/327

Table 1. The group corrections dt, dφ, and dz.

Group	0	2	4	6	8	10	12	14	16	18	20	22	Closing error
dt(0.0001^s)	–14	–19	0	2	–9	11	1	5	12	6	12	–7	–16
σ_t(±0.0001^s)	7	7	7	7	7	7	7	7	7	7	7	7	24
dφ(0.001″)	11	–6	–6	20	–15	–16	3	–2	13	9	1	–11	–92
$\sigma_{d\varphi}$(±0.001″)	10	10	9	9	9	9	9	9	10	10	10	10	33
dz(0.001″)	19	–10	–15	–16	3	3	25	6	–4	6	–7	–10	91
σ_{dz}(±0.001″)	7	7	7	7	7	7	6	7	7	7	7	7	24

From Table 1, we can see that the closing error of dz is very small.

2.1. The reduction of star residuals

The fundamental equation of observation is

$$15X\cos\varphi_0\sin A + Y\cos A - Z + \delta h = 0, \quad (1)$$

where

φ_0 – the adopted value of the latitude at the site of the instrument;

A – the azimuth of the observation, measured eastwards from the north;

X – the observed clock correction;

Y – the correction of latitude;

Z – the correction of instrumental zenith distance;

δh – a known term which is related to the position of the instrument and systematic errors in the observation.

As the Eqs. (1) are not strictly verified in the least square method of resolution, each of them gives a residual v which can be computed as:

$$v = 15X\cos\varphi_0\sin A + Y\cos A - Z + \delta h. \quad (2)$$

There are 384 stars selected from the Hipparcos catalogue in 12 fundamental groups. The corrections of astronomical time, latitude, zenith distance and residuals are obtained by observing the stars of fundamental groups and by solving for each fundamental group the system of Eqs. (2). The residuals of the catalogue stars, observed at the same epoch, are computed applying these corrections. Then, the mean values of the star residuals are computed by weighted means. The weight P is computed from the formula:

$$P = \frac{0.1}{\sigma^2}, \quad (3)$$

where σ is the precision of a single star observation in the reference group of stars.

2.2. The reduction of position correction of stars

Assuming that V_e and V_w are the residuals reduced to the mean instrumental system and considering the instrumental system errors at both eastern and western transits, we obtain the equation defining the position corrections (Debarbat & Guinot 1970; Li 1983; Lu et al. 1980):

$$\Delta\alpha = \frac{V_e - V_w}{30\cos\varphi_0|\sin A|}, \quad (4)$$

and

$$\Delta\delta = -\frac{V_e + V_w - 2K}{2\cos q}, \quad (5)$$

where q is the parallactic angle of the star when it transits the almucantar of the astrolabe.

The term $2K$ can be computed from

$$K = \frac{1}{2}(V_e + V_w)_{q=90^\circ}. \quad (6)$$

Only the stars with $|\cos q| < 0.2$ (in this catalogue there are 1162 such stars) are used to computed $2K$. The weighted mean value of this term is: $2K = -0.003'' \pm 0.002''$.

3. Results

From Feb. 23, 1992 to Mar. 11, 2000, using the photoelectric astrolabe, we obtained 65 3790 observations of stars in 2382 days. From these data, 13 524 residuals are obtained with a mean precision of ±0.041″. 6762 position corrections of stars have been obtained using Eqs. (4) and (5) from double transits of these stars at both their eastern and western passages with average precisions ±3.0 ms and ±0.053″ in right ascension and declination, respectively. The $\Delta\delta$ for the stars with $|\cos q| < 0.3$ are not computed. The mean number of observations of each star is about 82. In the catalogue there are 69 radio stars. The mean number of observations of each radio star is about 299 (146 in the eastern passage, 153 in the western passage).

3.1. The group corrections

With the results of PA II from Feb. 1992 to Mar. 2000, the group corrections of dt, dφ and dz are computed by the chain method. The results are given in Table 1.

3.2. The frequency distributions of $\Delta\alpha$ and $\Delta\delta$

The frequency distribution of $\Delta\alpha$ and $\Delta\delta$ are given in Tables 2a and 2b respectively.

Table 2a. The frequency distribution of $\Delta\alpha$.

	$\lvert\Delta\alpha\rvert$(ms)	00–05	05–10	10–15	15–20	20–25	25–30	30–35	>35
Hipp	N	3710	1553	537	214	93	38	11	0
	%	60.3	25.2	8.7	3.5	1.5	0.6	0.2	0
CAMC4	N	156	123	88	72	39	31	18	24
	%	28.3	22.3	16.0	13.1	7.1	5.6	3.3	4.4

Table 2b. The frequency distribution of $\Delta\delta$.

	$\lvert\Delta\delta\rvert$(0″.01)	00–7.5	7.5–15	15–22.5	22.5–30	30–37.5	37.5–45	45–52.5	>52.5
Hipp	N	2204	1031	386	189	73	49	20	0
	%	55.7	26.1	9.8	4.8	1.8	1.2	0.5	0
CAMC4	N	81	53	61	42	29	15	17	31
	%	24.4	16.0	18.4	12.7	8.7	4.5	5.1	9.3

From Tables 2a and 2b, we can see that the position corrections for about 97.7% and 96.4% of the Hipparcos stars are less than 20 ms in $\Delta\alpha$ and 0.30″ in $\Delta\delta$ respectively.

Table 3a. The systematic corrections (CPASJ3−Hipp) $\Delta\alpha_\alpha$ and $\Delta\delta_\alpha$.

α^h	0	1	2	3	4	5	6	7	8	9	10	11
$\Delta\alpha_\alpha(0.0001^s)$	–4	–12	–15	–14	–11	–7	–1	4	8	13	14	10
$\Delta\delta_\alpha(0.001'')$	6	7	10	10	6	0	0	–1	–5	–10	–17	–23
α^h	12	13	14	15	16	17	18	19	20	21	22	23
$\Delta\alpha_\alpha(0.0001^s)$	5	3	1	–2	–2	1	4	4	2	1	4	3
$\Delta\delta_\alpha(0.001'')$	–20	–10	0	1	0	4	9	10	5	2	4	6

Table 3b. The systematic corrections (CPASJ3−Hipp) $\Delta\alpha_\delta$ and $\Delta\delta_\delta$.

δ°	–2.5	–5.0	–7.5	–10.0	–12.5	–15.0	–17.5	–20.0	–22.5	–25.0	–27.5	–30.0
$\Delta\alpha_\delta(0.0001^s)$	11	10	8	3	1	0	1	0	–1	–1	0	1
$\Delta\delta_\delta(0.001'')$	–22	–13	–4	3	8	11	10	8	6	5	–2	
δ°	–32.5	–35.0	–37.5	–40.0	–42.5	–45.0	–47.5	–50.0	–52.5	–55.0	–57.5	–60.0
$\Delta\alpha_\delta(0.0001^s)$	1	1	–1	–3	–5	–6	–6	–6	–4	–3	–1	6
$\Delta\delta_\delta(0.001'')$						–6	–11	–15	–16	–8	4	22

3.3. The systematic corrections

By the analytic method (Bien 1979; Working Group of GCPA 1983) and adopting the $\Delta\alpha$ and $\Delta\delta$ of Hipparcos stars obtained from the double transits, the systematic corrections of the catalogue of stars (CPASJ3−Hipp) are analyzed. The systematic corrections on the right ascension and declination, $\Delta\alpha_\alpha$, $\Delta\delta_\alpha$, $\Delta\alpha_\delta$, $\Delta\delta_\delta$ are given in Tables 3a, and 3b, respectively.

4. The description of the catalogue

The catalogue (CPASJ3) will be available at the CDS. In the catalogue, the description of each column is given as follows:

1: No: Number in CPASJ3;
2: Hipp: Number in Hipparcos (recorder: 1–6156), FK5 (recorder: 6157–6164), SRS (recorder: 6165–6211), CAMC4 (recorder: 6212–6762), respectively.
3: Mag: Visual magnitude;
4: Sp: Spectral type;
5: α_{2000}: right ascension of reference catalogue for epoch and equinox J2000.0;
6: Proper motion of right ascension (unit: second/century);
7: δ_{2000}: declination of reference catalogue for epoch and equinox J2000.0;
8: Proper motion of declination (unit: as/century);
9: $\Delta\alpha$: position correction of right ascension in unit of 0.001^s;
10: $\sigma_{\Delta\alpha}$: mean error of the correction on right ascension in unit of 0.001^s;
11: $\Delta\delta$: position correction of declination in unit of 0.01″;
12: $\sigma_{\Delta\delta}$: mean error of the corrections on declination in unit of 0.01″;
13: Ne: number of observations in the eastern transit;
14: Nw: number of observations in the western transit;
15: Epoch: mean epoch of observations.

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