DETERMINATION OF PROPER MOTIONS OF CIRCUMPOLAR STARS BY USING IMAGES FROM UKRVO PLATE ARCHIVES

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ABSTRACT. UkrVO plate archives contain information obtained at different time periods and in different observatories for the same regions of the sky [3, 5, 6, 7, 8]. It allows us to carry out joint processing of plates and to receive new results for interesting objects. To obtain proper motions of stars in circumpolar areas, we selected 34 photographic plates from the RI NAO archive and 161 plates from the archive of the MAO NAS. A mean epoch difference between the plates from these archives is 55 years. Scanning of the plates and data processing were independently carried out by both observatories. A catalog of equatorial positions for 195 thousand stars up to 15^m was compiled in the RI NAO (black dots in Fig. 1). A catalog of equatorial positions for 1050 thousand stars up to 16.5^m was compiled in MAO (gray dots in Fig. 1). A comparison of positions for common stars contained in these catalogs was conducted. A catalog of proper motions for 30 thousand common stars up to 15^m was compiled using these two input catalogs. The obtained result suggests the advisability of processing of all observations to receive proper motions of stars up to 14-15^m in the declination zone of $65°$ to $90°$.

Keywords: Astrometry – Proper motions – Astronomical data bases – Catalogs – Virtual observatory tools.

1. Introduction

We selected photographic plates containing circumpolar stars in declination zone of $65°$ to $90°$. All plates in the RI NAO archive were obtained with the Zonal Astrograph (ZA, D/F = 12/204, 101"/mm, FoV 5°x5°). Selected plates from the MAO archive were obtained with the Double Wide-angle Astrograph (DWA, D/F = 40/200, 103"/mm, FoV 8°x8°). The plates were obtained with up to four fold overlap in MAO and usually without overlapping in the RI NAO. Therefore, the same star was observed two to four times in the MAO and one or two times in the RI NAO.

2. Virtual observatory tools

We compiled both catalogs in accordance with the VO-Table standard, which was produced and endorsed by the Executive Committee of the International Virtual Observatory Alliance. Usage of the VOTable standard allows us to apply wide range of VO tools to visualize and examine tabu-lar data. For example, Aladin sky atlas allowed us to visualize obtained equatorial positions, which are shown in Figure 1. Tool for OPerations on Catalogues And Tables (TopCat) allowed us to carry out cross correlation of stars contained in different astrometric catalogs and to examine linear correlation of proper motions for found common stars.
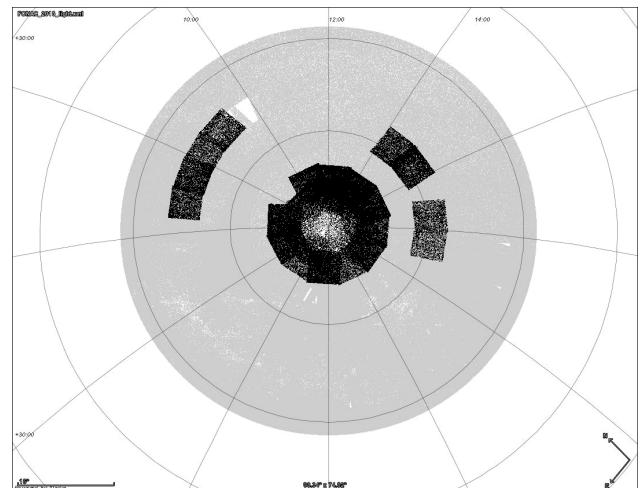

Figure 1: Equatorial positions of stars from two catalogs.

3. Data processing

The mean first epoch of 34 selected plates is 1930.3. Total number of plates for the first epoch of observations of circumpolar stars in the RI NAO archive is 196. The mean second epoch of 161 selected plates is 1985.7. The MAO archive contains about 2000 plates in the declination zone of $65°$ to $90°$. These plates were obtained during the observation campaign of FON project. The Russian or Ukrainian acronym FON stands for Photographic Survey of the Northern Sky.

Each selected plate from the MAO archive was scanned only once with a resolution of 1200 dpi. Each selected plate from the RI NAO archive was scanned five or six times with a resolution of 1200, 1500 or 1600 dpi. As the result of plate scanning at the MAO, we obtained two to four equatorial positions for every star. The number of positions depends on number of available plates, which cover a given region of interest (ROI) in the sky. As the result of plate scanning at the NAO, we obtained six to twelve equatorial positions for each

star. The number of positions depends on number of scans for one or two available plates in a given ROI. Both observatories conducted the raw image processing by using the same procedures and MIDAS/ROMAFOT package to obtain (X, Y) coordinates [4]. Both observatories carried out astrometric reduction in the Tycho-2 system by using different software, namely 00plate in MAO and plate_gr in NAO [1] to compare obtained results of data processing.

4. Comparison of catalogs

The catalog of positions for 195 thousand stars up to 15^m was compiled in the RI NAO. The catalog of positions for 1050 thousand stars up to 16.5^m was compiled at the MAO. Numbers of stars versus magnitude are shown in the left part of Figure 2 as empty and filled circles for the RI NAO and the MAO catalogs respectively. Common ROI in the sky for both catalogs are shown in Figure 1. Numbers of stars in the common ROI are shown in the right part of Figure 2 as filled and empty circles for the RI NAO and the MAO catalogs respectively.
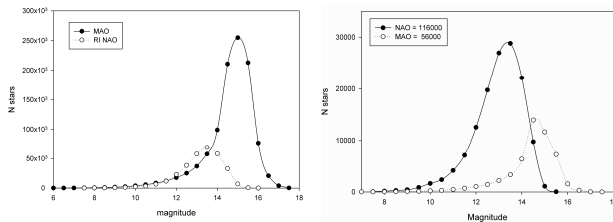

Figure 2: Number of stars for two input catalogs (left) and number of stars in common ROI (right) vs magnitude.

Standard deviations (SD) of positions of input catalogs are $\sigma_\alpha = \pm 0.24''$ and $\sigma_\delta = \pm 0.23''$ for the MAO catalogue, and $\sigma_\alpha = \pm 0.10''$ and $\sigma_\delta = \pm 0.17''$ for the RI NAO. Inner accuracies of equatorial positions versus declination are shown in Figure 3 for both input catalogs. The plate_gr software used in NAO provides us better results than 00plate software used in MAO, especially near 90° (Figure 3).
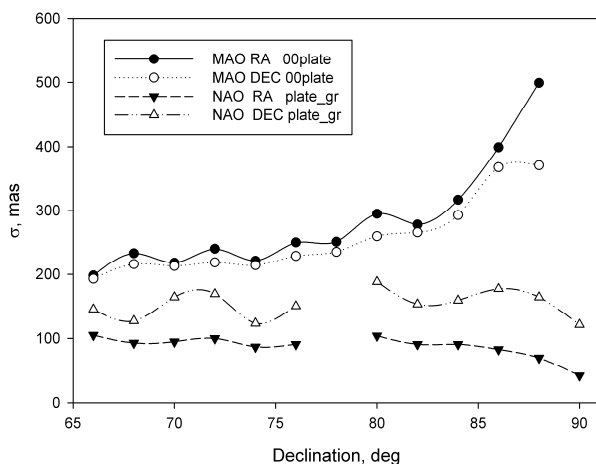

Figure 3: The SD of equatorial positions vs declination.

Using these two input catalogs as the first and the second epoch of observation, we obtained a resulting ZA_DWA catalog of positions and proper motions for about 30 thousand common stars. Number of stars versus magnitude for the ZA_DWA catalog is shown in the left part of Figure 4. We calculated inner accuracies of equatorial positions for

the ZA_DWA catalog. The SD of positions in right ascension (RA) and declination (DE) are ±73 mas for both equatorial coordinates. The SD of equatorial positions versus magnitude are shown in the right part of Figure 4.
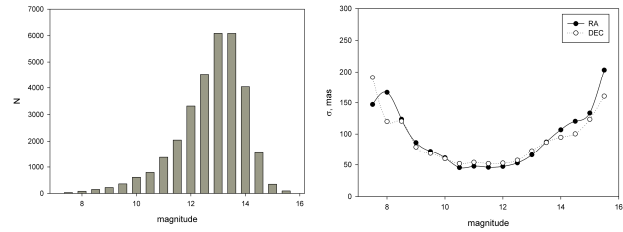

Figure 4: Number of stars (left) and SD of positions (right) in the ZA_DWA catalog vs magnitude.

We compared proper motions for the common stars in the ZA_DWA and Tycho2 catalogs. TopCat allowed us to find common stars for these catalogs and to calculate parameters of linear correlation (LC) for proper motions of stars in RA $-$ $\mu_\alpha \cdot \cos\delta$ and DE $-$ μ_δ. The coefficients of LC in $\mu_\alpha \cdot \cos\delta$ (Figure 5) and μ_δ are equal to 0.92 and 0.94 respectively for about 16 thousand common stars.
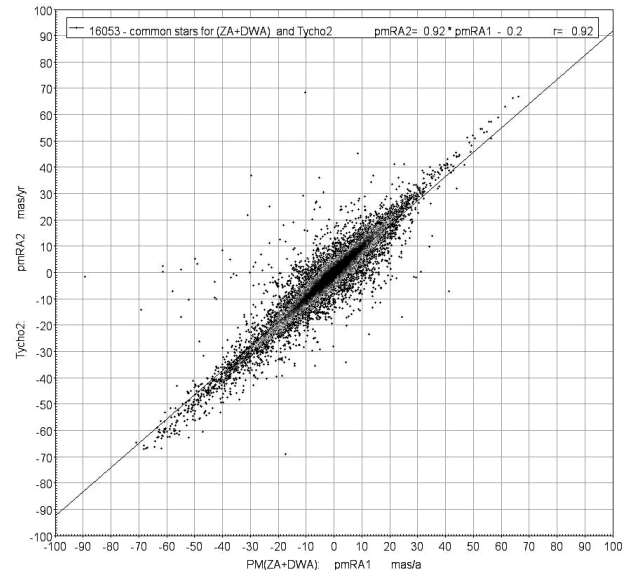

Figure 5: LC of $\mu_\alpha \cdot \cos\delta$ for our and Tycho2 catalogs.

The obtained result suggests the advisability of processing of all observations to receive proper motions of stars up to 14-15^m in the declination zone of 65° to 90°.

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