

ASTROMETRY OF χ AND h PERSEI BASED ON PROCESSING OF DIGITIZED PLATES OF ARCHIVE OF THE ASTRONOMICAL INSTITUTE OF THE ACADEMY OF SCIENCES OF THE REPUBLIC OF UZBEKISTAN

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ABSTRACT. Work is done with Epson Expression 10000XL scanner of Astronomical Institute (AI) of the Academy of Sciences of Uzbekistan. The plates were exposed with the Normal astrograph (D/F = 330mm / 3467mm, M = 59.56"/mm). The digitization of plates with (16x16) cm in size was made with resolution of 1200 dpi (1px = 1.25"). Test research was done using plates at first (1935.0) and second (1976.9) epochs in the sky area around the χ and h Persei clusters (field of view is 2°x2°). Coordinates and B-magnitude of stars were obtained using TYCHO-2 as the reference catalog. Errors of coordinate differences and proper motions for reduced and reference stars are respectively $\sigma_{\alpha\delta} = \pm 0.074''$ and $\sigma_{\mu\alpha\delta} = \pm 0.0018''/\text{year}$ (655 stars). Errors of photometry are $\sigma_m = \pm 0.065^m$ and $\sigma_B = \pm 0.208^m$ for internal convergence and in comparison with TYCHO-2 catalog. Comparison with UCAC4 catalog for 8123 stars with $B \leq 17.5^m$ gave us errors of $\sigma_{\alpha\delta} = \pm 0.28''$, $\sigma_{\mu\alpha\delta} = \pm 0.0075''/\text{year}$ and $\sigma_m = \pm 0.139^m$ for the equatorial coordinates, proper motions and magnitudes, respectively.

Key words: astrometry – methods: data analysis – proper motions – (Galaxy:) open clusters and associations: individual (χ, h Persei)

1. Introduction

Archive of Astronomical Institute (AAI) of the Academy of Sciences of Uzbekistan has about 10,000 plates. Astro negatives were exposed with the Normal astrograph from 1895 to 1976 and from 1976 to 1985 using the Double Zeiss Astrograph of Kitab Observatory. The archive contains about 3,000 plates produced before 1963, including the following observational programs: areas with galaxies – 1100 plates, minor planets – 1100, major planets – 60, planetary nebulae and star clusters – 150, comets – 200, variable stars – 200; other – more than 150 plates. Further work was carried out on the second epoch for favorites areas, such as open and globular clusters and in the areas of peculiar stars. Regular observations of the major planets

(Jupiter, Saturn and Uranus) and their satellites were carried out before the 1980s. Long exposures became impossible at this period of time due to a significant increase of light pollution in Tashkent. At one of the clear night in November 1976, M. M. Muminov received some great shots for the second epoch of χ and h Persei. It was the last observation with the Normal astrograph with long exposures. The Astronomical Institute carried out the next observations at Kitab Observatory using the Double Zeiss Astrograph (DAZ, D / F = 400mm / 3000mm), which was installed in 1975. The main scientific program of the DAZ was FON, which covered the equatorial zone of the sky (from -20° to +20°). More than 2,500 plates were obtained during the FON program. In addition, the plates of (30x30) cm in size: close open clusters (50 regions), young star-forming regions (50 plates) were obtained. Astro negatives are a valuable wealth of the Institute, as some of them contain dozens of previously unexamined open clusters. At the initiative of V. S. Schevchenko, this instrument captured many photos of areas with variable stars, star-forming regions in the Milky Way. The total volume of the DAZ archive has more than 6000 plates.

In order to obtain the equatorial coordinates α and δ , proper motions μ_α and μ_δ and photometric B-magnitudes of stars, the authors decided to start a pilot research using the field around the cluster of χ and h Persei. These clusters has been studied by Muminov (1982, 1996). Test research of scanner was made by Muminov in 2012. Experience of processing of digitized records in order to obtain the equatorial coordinates of stars and the photometric magnitudes was set out in (Andruk, 2005, 2007, 2010; Golovnya, 2010; Yatsenko, 2011; Vavilova, 2010, 2011, 2012a, 2012b; Protsyuk, 2014).

2. Processing of the digitized astroplates

The plates of the first and second epoch №76 (1935.0) and №4209 (1976.9) from the AAI were digitized with the Epson Expression 10000XL scanner. The plates were exposed with the

AI Normal astrograph, the digitization of plates was made with a resolution of 1200 dpi (1px=1.25"). Rectangular coordinates X and Y, instrumental photometric magnitude and FWHM were obtained by software in the environment LINUX/MIDAS/ROMAFOT (www.eso.org/sci/software/esomidas). Reduction for the equatorial coordinates α , δ and stellar B-mag was carried in the system of TYCHO-2 catalog. To check overall accuracy characteristics of widely used TYCHO-2 and UCAC-4 catalogs (Zacharias, 2013), follow-up study was carried out. Internal errors of catalogs (for the equatorial coordinates σ_α and σ_δ , proper motions $\sigma_{\mu\alpha}$, $\sigma_{\mu\delta}$ and photometry σ_m) were found for a field of view of 3° with the center of the clusters χ and h Persei ($\alpha \approx 2^h20.7^m$, $\delta \approx 57^\circ08'$). So, 1680 stars in the TYCHO-2 catalog have the following mean errors: $\sigma_\alpha = \pm 0.060''$, $\sigma_\delta = \pm 0.067''$, $\sigma_{\mu\alpha} = \pm 0.0031''/\text{year}$, $\sigma_{\mu\delta} = \pm 0.0032''/\text{year}$, $\sigma_B = \pm 0.137^m$. Respectively, 41,726 stars in the UCAC-4 catalog are characterized by the following mean errors: $\sigma_\alpha = \pm 0.053''$, $\sigma_\delta = \pm 0.051''$, $\sigma_{\mu\alpha} = \pm 0.0051''/\text{year}$, $\sigma_{\mu\delta} = \pm 0.0049''/\text{year}$, $\sigma_m = \pm 0.157^m$. A comparison of the equatorial coordinates and proper motions of stars for these catalogs was made for the specified region of the sky. For 1496 common stars, the error of the differences for equatorial coordinates are $\sigma_{\alpha\delta} = \pm 0.072''$ and $\sigma_{\delta\delta} = \pm 0.068''$, the error of the differences of the proper motions are $\sigma_{\mu\alpha} = \pm 0.0027''/\text{year}$ and $\sigma_{\mu\delta} = \pm 0.0031''/\text{year}$. The values of the above errors can be used as a reference in evaluating the similar values obtained for the presented catalog of positions and proper motions of stars.

3. Creating the catalog of positions and proper motions

Catalog of positions and proper motions of stars was obtained as follows. Equatorial coordinates of stars for the first epoch α_{1i} , δ_{1i} and the second epoch α_{2i} , δ_{2i} were obtained for epoch of exposures t_1 and t_2 , but in the TYCHO-2 system on the equinox 2000.0. Differences of equatorial coordinates of stars $\Delta\alpha_i = \alpha_{2i} - \alpha_{1i}$, $\Delta\delta_i = \delta_{2i} - \delta_{1i}$, divided by the difference between the periods $\Delta t = t_2 - t_1 = 1976.9 - 1935.0 = 41.9$ years give us absolute proper motions $\mu_{\alpha i}$, $\mu_{\delta i}$. Equatorial coordinates of the stars for the epoch and equinox 2000.0 were obtained by adding the proper motions $\mu_{\alpha i}$, $\mu_{\delta i}$ (multiplied by $\Delta t' = 2000.0 - 1976.9 = 23.1$) to the equatorial coordinates for objects in 1976.9. The estimated accuracy of the equatorial coordinates and proper motions were derived from the comparison of similar values of the TYCHO-2 and UCAC-4 catalogs.

Comparison of the resulting equatorial coordinates α , δ and proper motions μ_α , μ_δ of our catalog (CAT), with the same data of TYCHO-2 gave the following results: errors of differences of the coordinates and the proper motions for calculated and reference stars are respectively $\sigma_{\alpha\delta} = \pm 0.074''$ and $\sigma_{\mu\delta} = \pm 0.0018''/\text{year}$. Errors of photometry are $\sigma_m = \pm 0.065^m$ and $\sigma_B = \pm 0.208^m$ for internal convergence and with comparison to TYCHO-2 B-mag. A similar comparison of our data with UCAC-4 catalog for the common 8123 stars with $B \leq 17.5^m$ gave errors of $\sigma_{\alpha\delta} = \pm 0.28''$, $\sigma_{\mu\delta} = \pm 0.0075''/\text{year}$ and $\sigma_m = \pm 0.139^m$ for the equatorial coordinates, proper motions and magnitudes respectively. Figure 1 shows the distribution of the proper motions μ_α , μ_δ for the region of the sky $2^\circ \times 2^\circ$ (χ h Persey, $\alpha \approx 2^h20.7^m$, $\delta \approx$

$57^\circ08'$). The panels on the left and right show 655 common stars of TYCHO-2 catalog and created catalog.

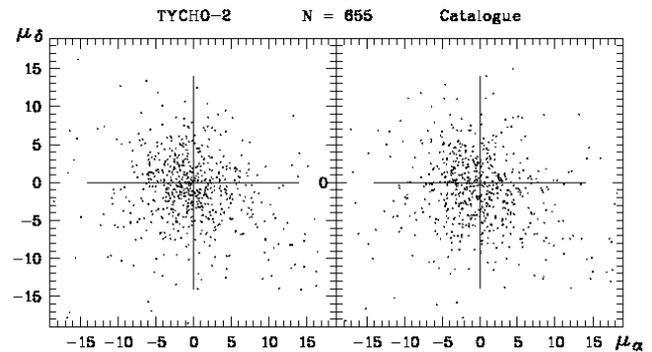


Figure 1: Distribution of the proper motions

4. Conclusion

For stars in the region of the sky around the clusters χ and h Persei (field of view $2^\circ \times 2^\circ$), we obtained the following results for the accuracy of the equatorial coordinates: $\sigma_{\alpha\delta} = \pm 0.085''$ and $\sigma_{\delta\delta} = \pm 0.056''$ for the first (1935.0) and second (1976.9) epochs, respectively.

Errors of coordinate differences and proper motions for common 655 calculated and reference stars are respectively $\sigma_{\alpha\delta} = \pm 0.074''$ and $\sigma_{\mu\delta} = \pm 0.0018''/\text{year}$.

Errors of stellar photometry are $\sigma_m = \pm 0.065^m$ and $\sigma_B = \pm 0.208^m$ for internal convergence and for comparison with TYCHO-2 B-mag.

Comparison of 8123 stars with $B \leq 17.5^m$ with stars of UCAC4 catalog gave errors $\sigma_{\alpha\delta} = \pm 0.28''$, $\sigma_{\mu\delta} = \pm 0.0075''/\text{year}$ and $\sigma_m = \pm 0.139^m$ for the equatorial coordinates, proper motions and magnitudes, respectively.

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